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Physicochemical properties of Cotton seeds oil and its comparison with released and improved cotton varieties in Ethiopia

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Cotton (*Gossypium hirsutum* L.) is one of the most ancient oil seed crops in the world. It is an ancient cultivated primarily for fiber and thought to have originated from Africa. A study was carried out to evaluate the variation of physiochemical parameters and quality attributes among oils from released and improved of different Ethiopian cotton varieties. Oils were extracted using n-hexane as solvent. Results indicated that contents of seed oil among the tested varieties varied from 12.22 % to 61.18%, moisture 3.40% to 8.00%, protein 13.64% to 21.73%, purity 93.50% to 99.50%, carbohydrate 9.65% to 60.50%, hundred seed weight 7.725 to 13.61%, while ash 3.77% to 5.95%. The physical and chemical characteristics among the tested oils varied as: refractive index (1.4590–1.468), acid value (1.71–12.09%), saponification value (181.03–199.32 mg KOH/g) and specific gravity (0.81–1.14%). Results indicated that a significant variation were shown for most of the physicochemical properties among fourteen (14) cotton verities oils which can be mainly linked to the specific genetic makeup of each variety as well as the agro-climatic conditions of the harvest. Cotton variety of Sile-91 was showed better nutritional status due to the higher quantity of oil parameter like crude fat (oil contents) and cotton variety Carolina qu. was showed better nutritional statues due to low acid value, free fatty acid and high saponification value, refractive index and ester value as compared to other thirty varieties selected.

Keywords: Cotton, oil seed, quality, physiochemical parameters, carbohydrate, protein and free fatty acid.

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the most important ancient oil seed crops known to mankind in the world. Cotton is also a fiber, oil and protein yielding crop of global significance. It is cultivated in tropical and sub-tropical regions of more than 80 countries of the world. The major cotton producing countries are USA, China, India, Pakistan, Uzbekistan, Turkey, Brazil, Greece, Argentina and Egypt. These countries contribute about 85% to the global cotton production. Cotton an ancient cultivated plant and thought to have originated from Africa (Abdullaev et al. 2013). Cotton is a major row crop grown primarily for fiber and oil seed. The cotton plant is unique because it is a perennial with an indeterminate growth habit and has perhaps the most complex structure of any major field crop. There are numerous varieties and ecotypes of cotton adapted to various ecological conditions. Cotton is cultivated on a worldwide basis for

both oil and protein. A better understanding of cotton growth and development in commercial production is important in the continuing efforts of growers to produce lint and seed yield more efficiently and profitably. Cotton is one of the most important of the vegetable fiber crops where the majority of the world's fiber is obtained (Oosterhuis 2001).

In Ethiopia, cotton is an important and major cash crop. Besides domestic use its export to other Countries are earning a lot of foreign exchange. It provides food, feed and fuel apart from fiber. It sustains a lot of people for livelihood. It provides raw materials to agricultural industry like ginning factories, textile and edible oil mills etc, thus it rightly be called the backbone of Ethiopian economy (Magdoff and Tokar 2010). In Ethiopia during 2003-04, it was cultivated on an area of 2989 thousand hectares with the production of 10048 thousand bales (Anonymous, 2004). The average yield of cotton (571 kg ha-1) in Ethiopia is very low as compared to that of the leading cotton producing countries in the world like USA, Egyptand Italy etc. The low per hectare yield may be attributed to several factors like low land holdings, poverty of farmers, lack of improved and resistant cultivars to diseases and insect pests, weeds and lack of growers know-how about the advanced package of technology concerning crop production and protection. Most common cause of low productivity is the cultivation of inferior varieties (Khan et al. 2007). Trébuil (Trébuil et al. 1993) is also of the same view that evaluation of cotton varieties for yield and fiber related parameters like G.O.T %, lint quality and fiber length is of paramount importance keeping in view the cotton production. Performance of cotton cultivars for yield components and fiber related traits should help to develop breeding strategies to improve yield, yield stability, and fiber quality (Bibi et al. 2003). In Ethiopia cotton is grown both in irrigated and rained agro ecologies. Crop development programs in Ethiopia are small and little progress has been made during the past 50 years.

Vegetable oils being an important ingredient of our diet act as a source of essential fatty acids and nutrition and can be extracted from a variety of plant seeds such as cotton, soybean, sesame, sunflower, safflower, palm, corn and canola (McKevith 2005). One of the important oil seed crops namely Cotton is a member of the Leguminosae family [sub-family Papilionoideae]. The plant is annual, generally grows to a height of 20–180 cm, and has white flowers. Fats and oils have been one of the most important components of human food since many years ago. Oil seeds are the most important products which contain vegetable oil and have a special role in agriculture. These high cost products are cultivated all over the world. Their importance is either due to oil contents and nutritive protein materials which are consumed as animal and human foods after oil extraction. The oil seeds are important products for global trading and they are the most important agricultural products after meat and cereal. Development of oil technology in the world has had significant effects on the oil consumption. The oil consumption has been increased steadily. Increasing oil seed fields' area and cultivation of new oil seeds are two main strategies to maintain the supply of edible oil (Al-Bakri 2017).

Fourteen cotton varieties investigated in the present study were grown at Ethiopian institution of Agricultural Research, Addis Ababa, Ethiopia for released and improved varieties. As the oil yield and the physicochemical properties and attributes of the oils can vary among different varieties of oil seeds with respect to their genetic makeup (Clemente and Cahoon 2009), so a need exists to investigate such variations with regard to different cotton cultivars. Until now, a full characterization and comparison of the quality attributes of the oils produced from seeds of mentioned locally cultivated cotton varieties has not yet been investigated. The main objective of the present study was to conduct a detailed analysis and to assess the variations in physicochemical characteristics of cotton seed oils of different varieties cultivated in Ethiopia. The main theme behind carrying out this study was to convey information to the local growers and industrialists about the physicochemical attributes of the above varieties thus helping them in selection of the appropriate variety for cultivation and industrial processing at regional level.

MATERIALS AND METHODS

The study area

The experimental material included fourteen (14) varieties of cotton (Gossypiumhirsutum L.) were collected from different cotton growing regions of Ethiopia. The study was carried out at Werer Agriculture Research Center (WARC). The site is located in the Afar National Regional State, Amibara Woreda at Melka Werer town, which is 280 km in the north east of Addis Ababa. The experiment was conducted in randomized complete block design (RCD) with three replications in all physicochemical proprieties.

Collection of seeds and identification

Cotton seeds were collected from different cotton productivity areas of Ethiopia. The purity of seeds were identified and authenticated by Ethiopian Institute of agricultural research Werer national cotton research center, Afar region, Ethiopia. Seeds were obtained by removing/ breaking/ external cover mechanically. These seeds samples were cleaned with water and acid to remove the impurities and stored in chemistry laboratory for further analysis. All the physicochemical analysis was conducted under laboratory condition. The data were recorded on as purity, percent moisture, thousand seed,

ash, protein, carbohydrate, crude fat (oil contents), acid value and saponification value, refractive index, specific gravity/density, ester value and free fatty acid. The parameters taken under this study were as follows.

Moisture content

Moisture content of cotton varieties would be determined according to Association of Official Analytical Chemistry (AOAC, 2000) using the official method 925.09 by oven drying method (Chemists 2000). A crucible would be cleaned and dried in an oven at 105^{o}C for 1 hour and placed in desiccators to protect from moisture absorption. Weight of would be crucible (W1) would be determined. 5 gm samples of cotton seed flour would be weighed in the dry crucible (W2) dried at 105^{o}C for 3 hours and after cooling the sample in desiccators to room temperature it is would be weighed again (W3). The moisture content cotton seed flour would be calculated using the formula below.

$$\%\text{Mo} = \frac{W2 - W3}{W2 - W1} \times 100$$

%MO = percentages of moisture content
W2= weight of the crucible plus weight of fresh sample
W1= weight of the empty crucible
W3= weight of the crucible plus weight of the sample after oven dried

Ash content

The ash content would be determined by (AOAC, 2000) using the official method 923.03 (Toor and Savage 2006). Porcelain dishes would be placed in a muffle furnace for 30 min at 550 ^{o}C. The dishes would be cooled in desiccators (with granular silica gel) for some minutes at room temperature and weighed as (W1). About 2.5g of cotton seed flour fresh sample would be weighed and let's represented as (W2). Finally the crucibles with the weighed sample would be placed on a hot plate under a fume-hood and the temperature was slowly increased until smoking stops and the samples become thoroughly charred. Then dishes with sample (charred) would be placed inside the muffle furnace at 550^{o}C for 5 hours. After the time finished the crucible would be cooled in desiccators for 1 hour. Then the crucible after cooling would be reweighed and represented by (W3) and the final ash content would be determined using the equation below.

$$\%\text{Ash} = \frac{W3 - W1}{W2 - W1} \times 100$$

%Ash = percentages ash content
W2= weight of the dishes plus weight of fresh sample
W1= weight of the empty dishes
W3= weight of the crucible plus weight of the sample after oven dried

W3= weight of the crucible plus weight of the sample after oven dried

Crude protein content

Cotton seed crude protein content would be determined according to (AOAC, 2000) using the official by the Kjeldhal method (Chemists 2000). Fresh samples of 0.5g would be taken in a test tube and 6ml of concentrated sulfuric acid would be added and mixed, and 3.5 mL of 30% hydrogen peroxide would be added step by step. Three gram of catalyst mixture (powdered 0.5 g of selenium metal with 100 g of potassium sulfate) would be added into each tube, and allowed to stand for about 10 minutes. The violet reaction had terminated, the tubes would be shaken and placed back to the rack. After the temperature of the digester reached 370 ^{O}C, the tubes should be lowered into the digester. The digestion would be allowed to continue until a clearsolution would be obtained, about 4 hours. The tubes in the rack would be cooled in a fume hood; 25 mL of de-ionized water would be added, and shaken to avoid precipitation of sulfate in the solution. A 250mL conical flask containing 25 mL of boric acid, 25 mL of de-ionized water and an indicator solution would be placed under the condenser of the distiller with its tips immersed into the solution. The above digested solution would be transferred into the sample compartment of the distiller. Sodium hydroxide solution (40%) would be added (40 mL) into the digested and diluted solution. The distillation process would be continued for some minute until a total volume reached between 250 ml. The tip of the distiller would be rinsed with a few milliliter of water before the receiver would remove. Finally the distillate solution would be titrated using 0.1N hydrochloric acid until reddish color appeared. The crude protein would be determined using the formula below:

$$\%\text{N} = \frac{(V\ HCl\ sample - V\ HCl\ blank) \times N\ HCl \times 14.0}{Weight\ of\ sample(Wt.)} \times 100$$

%Protein = %N X 6.25

Where:

%N= percent of nitrogen
N = is the normality of HCL (0.1N), Wt. = weight of sample in gram.
14.0 = molecular weight of nitrogen
V HCl = volume consumed by the sample in liter to the end point of titration,
V HCl blank = Volume consumed by the blank (without sample)

Determination of Carbohydrates

The amount of carbohydrate content of cotton seed flour

samples would be determined by difference, which would be done by subtracting the sum percentage of moisture content, percent of ash, crude protein, crude fat, and crude fiber from 100.

$$\%\text{CHO} = 100 - [\%\, Moisture + \%\, Fat + \%\, Protein + \%\, Ash + \%\, Dietary\ fiber]$$

Where: % CHO = percentage of carbohydrate

Extraction of seed oil

The seeds were crushed and placed in paper bags. The sample placed in aPyrex glass Soxhlet extractor, attached with a water condenser and a Pyrex round bottomed flask (500 mL capacity). Extraction was carried out using a water bath with in n-hexane as extraction solvent. The crude fat of cotton seed flour would be determined using (AOAC, 2000) official method 4.5.01(Thiex et al., 2003). 2 g of cotton seed flour would be weighed using thimble and covered by purified cotton. Then 50 ml of n-hexane as solvent would be added. The sample with the solvent would be placed in the soxhlet extractor for 4 hours. After 4 hours remain solvent would be then evaporated using oven dry method and the pure extracted fat would cooled in a desiccator and weighed. Crude fat would be determined using the formula below:

$$\%\text{Crude fat} = \frac{Weight\ of\ dried\ fat}{Fresh\ sample\ (2\ g)} \times 100$$

After the oil extraction, the extra solvent was removed under vacuum in arotary evaporator machine (EYELA, N. N. Series fitted with an Aspirator and aDigital Water Bath SB-651, Japan) at 45°C. The solvent (hexane) and oil are separated using distillation at a temperature of slightly higher than the boiling temperature of hexane, which is recovered again for further extraction with fresh hexane. The oil was stored in the chemistry laboratory roomfor physico- chemical propertiesanalysis.

Analysis of oils physicochemical parameters

The extracted oils were analyzed for saponification value, acidic value, color index, ester value, refractive index, specific gravity/density and free fatty acid value following standard methods (Society 1997). The color of the oil was read using a Lovibond Tintometer (Tintometer Ltd., Salisbury, and Wiltshire, United Kingdom) equipped with a1-inch cell. Determination of saponification value (SpV) was carried out using the method described by AOAC (2000) (Soler-Rivas et al. 2007, Nguyen et al. 2013). Two grams of the oil sample was added to a flask with 30 cm^3 of ethanolic potassium hydroxide solution and was then attached to a reflux condenser and heated on a water bath for 1 hour with occasional shaking to ensure the sample was fully dissolved. After the sample had cooled, 1cm^3 of phenolphthalein indicator was added and titrated with 0.5M hydrochloric acid until a pink endpoint was reached. A blank determination was also carried out omitting the oil under the same condition and saponification value was calculated using the equation:

$$\text{Saponification Value} = \frac{\text{(b-a)x M x56.1}}{\text{Sample wight (g)}}$$

Where: a = sample titrate value
b = blank titrate value
M = molarity of the HCl
56.1 = molecular weight of KOH

The acid value was determined using the method described by Ronald (1991) (Soler-Rivas et al. 2007, Nguyen et al. 2013). Equal volumes (25 ml) of diethyl ether and ethanol were mixed together and 1 ml of 1% phenolphthalein indicator solution was added and was then neutralized with 0.1 M potassium hydroxide solution. The oil sample (between 1 to 10 g) was dissolved in the neutralized solvent mixture and titrated with 0.1 M potassium hydroxide solution with constant shaking until a pink color which persists for 15 seconds is obtained. The acid value is given as:

$$\text{Acid Value (AV)} = \frac{\text{Titrate value (ml)}\times 5.61}{\text{Wight of sample used (g)}}$$

Determination of Refractive Index (RI) was determined following method. Melt the sample if it is not already liquid and filter through a filter paper to remove impurities and traces of moisture. Make sure sample is completely dry. Circulate stream of water through the instrument. Adjust the temperature of the refractometer to the desired temperature. Ensure that the prisms are clean and dry. Place a few drops of the sample on the prism. Close the prisms and allow standing for 1-2 min. Adjust the instrument and lighting to obtain the most distinct reading possible and determining the refractive index or butyro-refractometer number as the case may be (Marín et al. 2007, Kaswurm et al. 2013).

Determination of Specific gravity (SG) was conducted following method. Fill the dry pycnometer with the prepared sample in such a manner to prevent entrapment of air bubbles after removing the cap of the side arm. Insert the stopper, immerse in water bath at 30^0C and hold for 30 minutes. Carefully wipe off any oil that has come out of the capillary opening. Remove the bottle from the bath, clean and dry it thoroughly. Remove the cap of the side arm and quickly weigh ensuring that the temperature does not fall below 30°C (Kimani 2013).

$$\text{Specific Gravity at 30 degree C / 30 degree C} = \frac{A-B}{C-D}$$

Where,
A = weight in gm of specific gravity bottle with oil at 30°C
B = weight in gm of specific gravity bottle at 30°C
C = weight in gm of specific gravity bottle with water at 30°C

The ester value was obtained by subtracting acid value from saponification value (Venu Gopal et al. 2015)

Statistical analysis

Data were statistically analyzed to find out significant differences of parameters among varieties analyzed by using one-way ANOVA (version 2.10). All measurements were done in triplicate and the results were recorded as mean ± standard deviation (SD). The results were analyzed by one-way ANOVA using SPSS version 15.0 (SPSS Inc. Chicago, IL, USA). Multiple comparisons between physicochemical parameters were done. Analysis of variance (ANOVA) was used to check the presence of significant difference at 95% confidence level between mean levels of physicochemical properties of in each cotton varieties. One way ANOVA was also used to compare whether there were differences in the mean levels of in each varieties and parameters among samples.

RESULTS AND DISCUSSION

The seeds of fourteen(14) (Dp-90, Cucurova, Cuokra, Carolina qu., Sile 91, Arba, Bulk-202, Stam-59, HA/YD-211, YD-670, YD-206, YD-195, Cludia and Ionia) of cotton varieties were used in this study which were obtained from Werer Agricultural Research Center (WARC), Afar region, Ethiopia. The detail information including fiber quality is presented in Table 1.

The physicochemical analyses of oils are mainly made from the stand point of their edible as well as industrial uses. The quality of vegetable oils and production of cotton varieties can be judged by the knowledge of their physical and chemical characteristics. Analysis of variance for different cotton varieties and physicochemical properties related traits viz, as purity, percent moisture, color, ash, protein, carbohydrate and crude fat (Oil contents) are presented in Table 2. Significant differences ($P \leq 0.05$) among various varieties were observed for all traits.

Moisture contents

Data regarding moisture contents as presented in Table-2 revealed significant differences for moisture contents among the different cotton varieties. The maximum moisture content was recorded in Claudia (8.00%), while the minimum moisture content was recorded in YD-206 (3.40%). Similar results were found by (Özarslan 2002) who found such variation in moisture contents among different cotton varieties. The difference in moisture contents may be due to genetic nature of different cultivars. The so called critical moisture level for the beginning of rapid spoilage is relatively higher in seeds of low oil contents and relatively low for high oil content seeds. Moisture content in the seeds depends upon the maturity and quality of seeds. The moisture contents of seed determine the ability of all seeds to be stored well.

Ash contents

The maximum ash content was recorded in Bulk-202 (5.95%), Dp-90 (5.83%) and Carolina qu. (5.83%) varieties were comparable with others varieties ranged from 3.77 to 5.95% (Table-2). However, the lowest ash content was recorded in Stam-59 variety. The variation of ash content in varieties might be due to varietals character. The results are in line with the findings of (Rashid et al. 2009) who also observed significant difference in ash content among different cotton cultivars.

Crude protein contents

Data regarding crude protein content as presented in Table-2 revealed significant differences for crude protein content among different cotton cultivars. The maximum crude protein content was recorded in Cludia (21.73%) variety comparable with others cotton varieties. The difference in crude protein content may be due to genetic nature of different cultivars and application of fertilizers through different management system.

Carbohydrate contents

The maximum carbohydrate contents (Table-2) was recorded in YD-206 (60.50%) variety and minimum carbohydrate content was recorded in Sile-91(9.65%) variety. However, it was found statistically highest significant difference compared to other varieties. The carbohydrate content has an interaction of many factors such as moisture content, ash content, crude protein and fiber content. The carbohydrate content of showed high significant difference and the results showed a good agreement that has been reported by (Jaquet et al. 1982) of between cotton cultivars.

Percentage oil yield

The percentage yield of hexane-extracted oil content from different varieties of cotton seeds were founds to be in the range of 12.22–61.18%. A significant variation was observed for oil content among the cotton seed samples analyzed. The oil content (61.18%) was considerably higher for Sile-91 variety and lower (12.22%) in the seeds of variety YD-206 special. The oil content is a quantitative trait whose variability is conditioned with genetic

Table 1: Detail information of the mean performance for yield and fiber related parameters of different cotton varieties.

	Fiber quality				
Varieties	Micronaire	UHM(mm)	UI(%)	SIF	Stre(g/tex)
DP-90	5.09	26.5	82.3	13.7	24.1
Stam-59A	4.64	31.05	84.3	11.4	31
Ionia	3.8	31.2	85.0	10.5	30.9
YD-670	3.55	33.75	85.5	6.8	34.5
YD-195	3.46	31.06	82.7	12.8	35
YD-211	3.17	32.22	84.6	10.3	35.5
Stoneville	4.11	29.96	80.7	13.93	32.43
Arba	4.3	29.5	83.7	11.7	28.7
Carolina queen	3.7	28.1	82.8	12.4	26.6
Cucurona-1518	3.8	27.4	80.6	13.4	23.7
Cu-okra	3.7	26.4	80.5	14.6	23.1
Sille91	4.1	28.5	83.4	11.3	26.3
Claudia	4.36	30.9	84.6	13.64	32.4
Bulk 202	3.9	27.3	83.1	13.6	26.6

Source = Werer Agricultural Research Centre (WARC), 2015.
UI = fiber length uniformity (expressed as uniformity index UI[%]), SIF = short fiber content (SF[%]) , UHM= Fiber length (expressed as upper half mean UHM[mm], Stre= fiber strength (as bundle strength STR[cN/tex])

Table 2: Analysis of variancefor different cotton varieties and physicochemical properties related traits of released and improved cotton varieties in Ethiopia.

Varieties	Color	Ash	CF	Pr	MC	CHO	Pu
Dp-90	Light red	5.83±0.200^{a}	21.66±0.572^{fgh}	17.50±0.00^{f}	6.20±0.200^{f}	48.81±0.172^{cd}	97.50±0.500^{de}
Cucurova	Light red	5.50±0.320^{abc}	23.24±0.750^{efg}	19.69±0.290^{de}	6.80±0.000^{c}	44.78±0.780^{de}	98.00±0.000^{b}
Cuokra	Light black	5.40±0.170^{abc}	23.07±0.550^{efg}	16.77±0.150^{b}	6.50±0.100^{d}	48.17±0.670^{cd}	98.00±0.500^{b}
Carolina qu.	Light black	5.83±0.210^{a}	30.59±1.360^{d}	21.22±0.220^{b}	6.40±0.000^{de}	36.27±0.360^{f}	97.50±0.050^{bc}
Sile-91	Light red	5.52±0.010^{ab}	61.18±0.130^{a}	17.65±0.290^{f}	6.00±0.200^{g}	9.65±0.630^{h}	95.50±0.500^{de}
Arba	Light black	5.20±0.160^{bc}	57.61±1.012^{a}	16.70±0.073^{g}	6.30±0.100^{ef}	14.19±0.828^{h}	93.50±0.500^{f}
Bulk-202	Light black	5.95±0.218^{a}	42.78±2.180^{b}	19.32±0.219^{e}	6.70±0.100^{c}	25.26±0.279^{g}	95.00±0.000^{e}
Stam-59	Light red	3.77±0.088^{e}	36.89±2.956^{c}	13.64±0.219^{h}	6.30±0.100^{ef}	39.4±0.500^{f}	99.50±0.500^{a}
HA/YD-211	Light red	4.51±0.201^{d}	16.65±0.450^{hi}	16.63±0.292^{g}	7.20±0.2000^{b}	55.02±0.500^{ab}	97.50±0.500^{bc}
YD-670	Light green	4.30±0.003^{d}	17.91±1.146^{gh}	20.34±0.219^{c}	6.50±0.100^{d}	50.95±0.500^{bc}	95.50±0.500^{de}
YD-206	Pink black	3.83±0.156^{c}	12.22±0.368^{i}	20.05±0.219^{cd}	3.40±0.000^{h}	60.50±0.010^{a}	97.00±0.000^{c}
YD-195	Green	5.06±0.591^{c}	19.33±0.612^{gh}	21.36±0.219^{ab}	7.10±0.100^{b}	47.15±0.339^{cd}	96.00±0.000^{d}

Table 2: Continuation

Cludia	Black greenish	5.12±0.520^{c}	25.05±0.324^{def}	21.73±0.146^{a}	8.00±0.000^{a}	40.10±0.698^{ef}	96.00±0.000^{d}
Ionia	Light red	3.80±0.065^{e}	27.59±0.184^{de}	17.50±0.292^{f}	6.50±0.100^{d}	44.61±0.641^{df}	96.00±1.00^{d}
Mean		4.98	29.68	18.58	6.42	40.35	96.61
LSD(0.05)		0.46***	5.66***	0.38***	0.20***	5.72***	0.77***
CV(%)		5.52	11.36	1.22	1.85	8.45	0.47

Where; Mc = Moisture content, CF = crude fate/oil content, Pr = protein content, CHO = carbohydrate content, Pu = Purity

Table 3: Analysis of variance for different cotton varieties and physicochemical properties related traits of released and improved cotton varieties in Ethiopia.

Varieties	SW	SG	RI	SpV	AV	EV	FFA
Dp-90	8.75±0.050i	0.91±0.003b	1.47±0.000a	190.03±0.079f	3.62±0.095f	186.40±0.174h	1.823±0.048
Cucurova	10.3±0.100f	1.14±0.002a	1.47±0.000a	194.02±72.576d	3.76±0.140f	190.26±0.150f	1.89±0.068f
Cuokra	10.70±0.040e	0.89±0.001e	1.47±0.001a	196.06±65.606c	3.77±0.180	192.30±0.290e	1.893±0.090
Carolina qu.	10.31±0.030f	0.81±0.001h	1.47±0.000a	199.32±63.501a	1.71±0.040i	197.61±0.220a	0.86±0.020i
Sile 91	10.10±0.010g	0.89±0.303e	1.46±0.000b	184.11±61.354g	2.75±0.070h	181.36±0.720j	1.38±0.030h
Arba	8.69±0.040j	0.90±0.001cd	1.46±0.001b	192.37±0.301e	3.23±0.133g	189.15±0.434g	1.26±0.067g
Bulk-202	9.85±0.150h	0.89±0.003de	1.46±0.000b	197.56±0.026b	4.5±0.129e	193.06±0.155de	2.26±0.065e
Stam-59	8.83±0.020i	0.90±0.000cd	1.46±0.000b	197.26±0.201b	2.92±0.123h	194.34±0.078bc	1.47±0.062h
HA/YD-211	11.11±0.095c	0.90±0.001cd	1.46±0.000b	198.07±0.720b	12.09±0.212a	185.98±0.508h	6.08±0.107a
YD-670	13.61±0.015a	0.91±0.002cb	1.46±0.000b	194.95±0.279d	5.71±0.121c	189.24±0.399fg	2.87±0.061c
YD-206	11.40±0.015b	0.89±.005de	1.46±0.001b	198.22±0.202b	4.82±0.228d	193.41±0.027cd	2.42±0.115c
YD-195	11.01±0.010d	0.89±0.005de	1.46±0.001b	181.03±1.711h	2.85±0.127h	178.18±1.837k	1.43±0.064h
Cludia	7.72±0.015k	0.84±0.015g	1.46±0.000b	190.26±0.156f	6.39±0.228b	183.87±0.384i	3.21±0.115b
Ionia	10.09±0.025g	0.85±0.007f	1.46±0.000b	197.97±0.806b	2.71±0.078h	195.26±0.728b	1.36±0.03h
Mean	10.17	0.90	1.46	193.66	4.34	189.32	2.19
LSD(0.05)	0.09***	0.01***	0.00***	1.03***	0.25***	1.08***	0.12***
CV(%)	0.51	0.72	0.00	0.32	3.38	0.34	3.38

difference between the varieties (Anwar et al. 2016). The oil content in cotton seeds from different varieties, ranging from 15.85–19.49%, was comparable with the findings of (Torres and Maestri 2006) and (Bahkali et al. 1998) who reported the oil content in different genotypes of cotton to be 15.84–21.35%, respectively. The difference of oil content may be the effect of management practices and it's genetically variability. The higher protein and lower oil concentrations in cotton seed may suggest there is a potential commercial use for fuzzless seed as a source for food (oil) and feed (cotton seed meal). The cotton varieties with high level of oil, protein and with low level of moisture and carbohydrate, this makes the variety potential source of edible oil. The low level of ash content indicative of low level of inorganic impurities and qualifies the oil as good source of mineral elements and cotton which have low level of moisture content is advantageous when shelf life is considered. Analysis of variance for different cotton varieties and physicochemical properties related traits viz, as seed weight, acid value, saponification value, refractive index, free fatty acid, ester value and specific gravity/density are presented in Table 3.

Cotton seed residues

Analysis of oil seed residues showed a good agreement compared with some conventional oil seed crops, the protein content of the presently analyzed cotton samples were showed closer those of safflower (20–22%), sunflower (16.5–19.6%) and cotton seed (19.40%) as reported in the literature (Rossell and Pritchard 1991). As expected, the oil seed samples high in oil content were generally found to be lower in protein, fiber and ash contents. The crushed cotton by product is suitable for animal feed and as human staple because of the spectrum of amino acids. The analysis showed the cotton meal (after oil recovery) to be a good source of protein with potential to be used in poultry feed as a cheaper source of calories (Silwal 2016). There were highly significant variations in moisture, ash, crude protein, carbohydrate and crude fat contents of cotton seeds among the varieties tested.

Physicochemical parameters of oils

The results obtained for the oil samples shown in Table 3 shows that the hundred seed Wight ranged between 7.72 – 13.61 g for cotton varieties samples. The highest seed weight was obtained in YD-760 and also the lowest seed weight was obtained in cludia variety. This shows that the moisture content is high in YD-760 rather than other varieties and estimates have high oil content in most of the oil samples. But, it may be varied within the effect of harvesting time and storage conditions. The oil color in terms of yellow and red units for different samples of cotton seed oils were in the range of 30–45 Y and 3.5–5.9 R. The intensity of the color of vegetable oils is linked with the presence of different pigments such as chlorophyll and carotenoids which are effectively removed during the processing (de-gumming, refining and especially bleaching) step of oil. The vegetable oils with low color values are better for edible and domestic applications (Anwar et al. 2016).

Values determined for the different physico-chemical attributes of oils were as follows; refractive index (1.46–1.47), specific gravity (0.81–1.14 g/cm3 at 36^{o}C), FFA (0.86–6.08%), saponification value (181.03–199.32%), and ester value (178.18–197.61 of KOH/g of oil). Values for refractive index are comparable with the findings of (Nagaraj 2009) who reported RI of 1.470 at 32^{o}C for cotton oil. Density and refractive indices of investigated oils in the present analysis were in close agreement with some other oilseed crops (Anhwange et al. 2012). The refractive index of the oil contained some double bond in fatty acid composition, that refractive index increase as the double bond increases (Kyenge et al. 2012).

The free fatty acid value of HA/YD-211 variety was showed high and lower in Carolina qu. variety. This implies that they contain low amount of fatty acids making them fit for edible purposes. High concentrations of free fatty acids are undesirable in vegetable oils because they can reduce the palatability and the shelf-life of the oil (Nkafamiya et al. 2010). There was highly significant difference between the refractive index of the different cotton oil samples. The range was between 1.46 – 1.47. These values obtained are in line with the results of some other literatures (Sreening 2013) and also within the standard limits set by NAFDAC and CODEX. The colors of the cotton oils were either light yellow, golden yellowor yellow red while the palm oils were reddish in color. These are acceptable colors of vegetable oils as reported by Anyasor (Anyasor et al. 2009). The odors of all the oils analyzed were unobjectionable and acceptable. There was no rancidity and mineral oil in all the oil samples analyzed as the oil samples were kept in a cool place and protected from light and air (Anyasor et al. 2009).

The ester values in the samples ranged between 178.18 – 197.61 mg KOH/g for cotton seed oil samples. The highest ester value was obtained in Carolina qu. and the lowest value was obtained in YD-195 cotton variety. The higher the ester value, the more intact the ester bond between the glycerol molecule and the fatty acids. Therefore, the oil samples analyzed are of high quality and can be stored for a longer time (Akinola et al. 2010). The saponification value of the oil samples ranged between 181.03 – 199.32 mg KOH/g for cotton oil samples. The highest saponification value was obtained in Carolina qu. cotton variety and the lowest saponification value was obtained in YD-195 cotton variety. The values obtained are in line with the standard guidelines set by NAFDAC and CODEX as well as some other literatures (Commission 1969). Studies show that the high saponification values indicate that the oils are normal triglycerides and will be useful in the production of soap (Yousefi et al. 2013). Saponification is only of interest if the oil is for industrial purposes, as it has no nutritional significance. But due to the fact that each fat has within the limits of biological variation, a constant fatty acid composition, determination of the saponification value is a reasonable means of characterizing the fat (Tan et al. 2002). The acid values of the vegetable oil samples ranged between 1.71- 12.09 mg KOH/g for cotton oil samples. HA/YD-211 cotton variety showed highest acidic value and Carolina qu. variety showed the lowest acidic value. Acid value of oil suitable for edible purposes should not exceed 4 mg/g (Tan et al. 2002). Low level of acidity is referring to suitable quality of oil (Yaakob et al. 2009).

CONCLUSION

Vegetable oils makes an important contribution to the diet of people, serving as a good source of lipid and fatty acids for human nutrition including the repair of worn out tissues, new cells formation as well as a useful source of energy. The results obtained shows that the cotton oils on average have high shelf lives and can be stored for long time, in addition to good nutritional values, with all falling within the standard limits set by NAFDAC and CODEX. Furthermore, the tested fourteen varieties of cotton were found to be quite different on the basis of variation in most of the important physico-chemical characteristics. The difference may be attributed to their different genetic properties. Cotton variety of Sile-91 showed better nutritional status due to the higher quantity of oil parameter like crude fat (Oil contents) and cotton variety Carolina qu. showed better nutritional statues due to low acid value, free fatty acid and high saponification value, refractive index and ester value as compared to other thirty varieties selected. It can therefore, be suggested that these vegetable oils pose no significant health risks to the consumers in Kaduna metropolis. Data of this study might be useful for oil chemists and breeders for further investigations. At the same time it might be helpful for local cotton growers/farmers and oil producers for the selection of the appropriate cotton variety for cultivation

and industrial processing. However, it is recommended that further studies should be carried out to determine other nutritional composition of various branded oils such as β-carotene, fatty acid compositions and also antimicrobial activities

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