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Physico-chemical and faty acid Composition determination of Canola Varieties cultivated in Ethiopian Agro-ecology

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Abstract: **This study was aimed to evaluate the chemical compositions of canola varieties in Ethiopia to generate baseline information for breeders, nutritionists, manufacturers and food service providers so that they will be able to choose the appropriate variety for their own purpose based on their chemical compositions. Three canola seeds used for Physico-chemical study and extraction of oil were collected from Ethiopian Institute of Agricultural Research (EIAR), Holeta Agricultural Research Center, Ethiopia. The seeds were sun-dried, milled and stored at 4 °C until needed for analysis. Oil from each sample was exhaustively extracted with a Soxtec™ 800 apparatus using hexane (boiling point range 40-60 °C) as the extractant. The protein and oil content of these varieties was found to be in the ranges of 20.02 - 22.92 % and 41.97-46.63 % respectively. Dodgar has significantly higher protein content followed by Belinda and Axan has significantly higher oil content among all varieties followed by Belinda. The residual oil obtained was characterized by investigating Physico-chemical parameters and results show that the extracted oils was liquid at room temperature, have average density (0.95-0.97), Refractive index (1.367-1.447), acid value (2.05-2.24), saponification value (175.2-182.8), iodine value (99.00-101.36), peroxide value (4.93 - 5.70). All varieties generally showed an appreciable amount of all the omega fatty acids (omega-3,-6, -9) but is specifically rich in omega-9 fatty acid with 61.48 to 62.11% oleic acid and unsaturated fatty acids with PUFA/SFA ratio between in the ranges of 2.94 (Belinda) – 3.08 (Dodgar) which in general, meets the requirement set by WHO/FAO to be greater than 0.4. This result of analysis confirms the standard specification and reveals that the extracted oil has good quality for consumption as well as industrial purposes and commercial applications.**

Keywords: **Canola oil, Physico-chemical Properties, Fatty Acid Composition, Quality, Varieties.**

1. INTRODUCTION

Rapidly increasing population and changes in dietary habits associated with urbanization increased demands for food and fuel. Rapeseed is an annual crop belonging to Brassicaceae family (Cruciferae) originating from either the Mediterranean area, Asia or Northern Europe. Today rapeseed is one of the top five oilseed crops cultivated worldwide (Miri, 2007, Khattab et al.,, 2012, Liersch et al., 2013). It is mainly utilized for its oil, which is one of the most common edible and healthy cooking oils due to its low content of saturated fatty acids (SFA, 7.0%), high content of the monounsaturated fatty acids (MUFA, 60.0%), and adequate content of polyunsaturated fatty acids (PUFA, 8.0 -12.0%) (WHO, 1994, Starner et al., 1999).

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Rapeseed has a short domestication history of 400–500 years (Pop et al., 2012). During the breeding history of rapeseed, the most outstanding event is the introduction of two traits, zero seed erucic acid and low seed glucosinolate content, so called double-low, canola quality. Brassica napus used to produce edible oil that is fit for human consumption because it has lower levels of erucic acid and glucosinolates (Pop et al., 2012).

Although rapeseed has high erucic acid content, with improved technologies of plants, levels of erucic acid reduced to 1-2% in the rapeseed oil then to zero erucic acid type (zero erucic). Accountable to the market needs, rape types produced for oil have no erucic acid and glucosinolates. Through decreasing of erucic acid content, the oleic acid proportion increased from 14-20 % to over 64%, and the linoleic acid from 13-15% to 24%, which increased the alimentary quality of rape oil (Pop et al., 2012, and Liersch et al., 2013).

Canola is one of the mostly patronized edible oils produced from the seed of any of the different varieties of rape plant including cultivars of Brassica napus L. and Brassica rapa. It has been growing in many countries for a long time and was introduced in to Ethiopia in the early 1970s (Hiruy et al., 1983) on an experimental basis from Northern Europe and Canada. Specifically these species were introduced from Germany, has the advantage of being earlier and more uniform than another Brassica species and may be more suitable for mechanization harvest. These are being promoted for large scale production in the highlands of Arsi Zone, Central shewa and similar agro-ecologies.

The goal of this investigation was to study the chemical composition and fatty acid profile of the extracted oils of canola varieties in Ethiopia.

2. MATERIALS AND METHOD

In this study three (3) major varieties of canola were collected from Ethiopian Institute of Agricultural Research (EIAR), Holeta Agricultural Research Center in 2016. The samples collected were brought to laboratory. Following the standard procedures the seeds were sun-dried, milled and stored at 4 ^{o}C until needed for analysis. Oil from each sample was exhaustively extracted with a Soxtec^{TM} 800 apparatus using hexane (boiling point range 40-60 ^{o}C) as the extractant after which they were subjected to physical and chemical characterization. All the physicochemical analysis were conducted under laboratory condition. The data were recorded on percent Moisture, Ash, Protein, Crude fiber, Carbohydrate, Crude fat (oil contents), Acid value, Saponification value, Refractive index, Specific gravity/density, Ester value, Peroxide, Iodine value and Free fatty acid. The parameters under study were expressed as follows:

Physicochemical parameters such as percent Moisture, Ash, Protein, Crude fiber, Carbohydrate, Crude fat (oil contents), Acid value, Saponification value, Refractive index, Specific gravity/density, Ester value, Peroxide, Iodine value and free fatty acid were analyzed.

2.1 Chemicals and reagents

Boric acid, NaOH, *n*-hexane, petroleum ether, KOH, Chloroform, Glacial acetic acid, Potassium iodide, Sodium thiosulphate, Phenolphthalein indicator solution, Standard HCl: approximately 0.5N, Absolute ethyl alcohol, Standard ethanolic KOH 0.1N, Solvent mixture of ethanol, Distilled water, H_2SO4, HCl, K_2SO4, CuSO4, Antifoaming agent, Deionized water, Na_2SO4, H_2O2, Bromocresol green and methyl red indicator used in the present study were purchased from Sigma Aldrich, Germany and Fisher Scientific, UK.

2.2 Proximate composition

2.2.1. Determination of moisture content

Moisture content was determined by oven dry method according to AOAC, 2000 official method- 925.09. Two grams of crushed sample was dried in the oven 105 ± 2 °C for 5 hrs. The weight difference shows the moisture content (AOAC, 2000)(Chemists, 2000).

2.2.2. Determination of ash content

The recommended methods of the association of official analytical chemists (AOAC, 2000) method - 923.03 were employed in determining the ash content. Ash content was determined by the incineration of 3.0 g samples to a constant weight in a crucible placed in a muffle furnace maintained at 550 ^{o}C for 6 hrs.

2.2.3. Determination of crude protein

The rape seeds of three major varieties of crude protein were analyzed. The crude protein was determined according to AOAC, using kjetec^{TM} 8400 analyzer unit apparatus. This was measured following the Kjeldahl method based on the total mineralization of the biological material in an acid environment, followed by distillation of nitrogen in ammonia form (AOAC, 2003). The total mass of vegetable protein was calculated using a conversion factor of 6.25. Crude protein (% total nitrogen x 6.25) was determined by Kjeldhal method, using 1.0 g sample.

2.2.4. Extraction of oil and determination of crude fat (oil contents)

The seeds were crushed using an electric blender. The oil was then extracted from each of the seeds using hexane by adopting the method described by association of official analytical Chemist (AOAC, 2000) method-45.01 (Committee, 2000) using soxtec^{TM} 8000. A quantity of 5 grams of the pulverized seeds were packed in a muslin cloth/ tumble and covered by cotton. The sample was inserted into the soxtec extractor and hexane was used as the extraction solvent. At the end of the extraction period, the solvent was recovered/ evaporated by placing container with the fat in an oven dried at 75 °C for one hour. The extract was transferred to desiccators for 30 mins and weighed. The weight difference gives the fat content of the sample (Committee, 2003).

2.2.5. Determination of crude fiber content

Crude fiber was determined by AOAC (2005) 945.16 method with some modification. 2.0 g of the sample was weighed into a beaker and 180 mL preheated, 0.128 M H_2SO_4 was added and boiled for 30 mins using a water pressure filter system. The moisture was filtered and the residue washed 3 times with hot water. The residue was collected and 150 mL preheated 0.22 M KOH was added and boiled for another 30 mins, the mixture was filtered and the residue washed on the water pressure system 3 times with acetone. The residue was collected in a crucible, dried at 130°C for 1 h and weighed. It was ashed in a muffled furnace for 3 hrs at 500°C and later weighed after cooling. This was calculated according to the Saeed et al (2013) reported.

$$\text{Crude fiber (\%)} = \frac{\text{Weight loss on ignitation}}{\text{Sample(s) weight}} \times 100$$

2.2.6. Determination of carbohydrate

Carbohydrate content was determined using the method described by (Ciabotti et al., 2016). The content of the available carbohydrate was determined by the following equation:

Carbohydrate = 100- [(Moisture + Crude Fat + Protein + Ash + Fiber)].

2.3. Determination of the physicochemical properties of the oils

The extracted oils were analyzed for Saponification value, Free fatty Acid, Acid value, Peroxide value, Iodine value, refractive index, and specific gravity following standard methods of AOAC (AOAC, 2000).

2.3.1. Determination of saponification value (SV)

This was carried out using the method described by AOAC (2000) (Kaswurm *et al*., 2013, Marín *et al*., 2007). 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 equation:

$$\text{Saponification Value} = \frac{(a - b) \times M \times 56.1}{\text{Sample weight (gm)}}$$

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

2.3.2. Determination of acid value (AV)

The acid value was determined using the method described by (Kaswurm, *et al*., 2013, Marín, *et al*., 2007). 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 gm) 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 was given as:

$$\text{Acid Value (AV)} = \frac{VC\ (mL) \times 56.1}{\text{Sample weight (gm)}}$$

Where V = Volume of standard potassium hydroxide (mL),

C = Concentration of potassium hydroxide,

2.3.3. Determination of Refractive Index (RI)

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 refracto meter 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 (Kaswurm *et al*., 2013, Marín *et al*., 2007).

2.3.4. Determination of specific gravity (SG)

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 ^{0}C 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, (Hamid and Mohan, 2009).

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

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

B = weight in gm of specific gravity bottle with at 30°C

C = weight in gm of specific gravity bottle with water at 30°C.

2.3.5. Determination of iodine value

Iodine value was determined according to Pearson (Pearson, 1981). 2 grams of oil sample poured into a dry glass stoppered bottle of 250mL capacity and 10mL of carbon tetrachloride was added to the oil. About 20 mL of Hanus solution was then added and allowed to stand in the dark for 30 min (Anyasor *et al*., 2009). 15 mL of (10%) Potassium Iodide was added followed by 100 mL of water and then titrated with 0.1M Sodium thiosulphate solution using starch as indicator just before the end point. Iodine value was calculated by using (Anyasor *et al*., 2009):

$$\text{Iodine value} = \frac{(V_2 - V^1) \times 1.269}{\text{Sample weight (gm)}}$$

Where: V_2 = titer value for blank, V_1 = titer value for sample(s)

2.3.6. Determination of peroxide value

2 grams oil sample was poured into a test tube and 1g of powdered Potassium iodide with 20mL of solvent mixture (glacial acetic acid and chloroform) was added. This mixture was then placed in boiling water bath for 30s. The content was poured into a conical flask containing 20 mL of 5% iodide solution. The test tube was washed with 25 mL of distilled water and then titrated with 0.002N Sodium thiosulphate solution using starch as indicator. Peroxide was obtained by using (Anyasor *et al*., 2009):

$$\text{Peroxide Value (PV)} = \frac{2\times (V_1 - V_2)}{\text{Weight of sample (gm)}}$$

Where V_2= Blank titer value, V_1 = Sample (s) titer value.

2.3.7. Determination of Ester Value

The Ester Value is the number of mg of potassium hydroxide required to saponify the esters in 1.0 g of the substance. If the Saponification Value and the Acid Value have been determined, the difference between these two represents the Ester Value (Singh *et al.*,2015), i.e.,

Ester Value = Saponification Value – Acid Value.

2.4. Fatty Acids Composition

The fatty acid profile of the oils was determined according to (IOC/T.20/N33, 2000) method by gas chromatography mass spectroscopy FID detection, previous preparation of the fatty acid methyl esters derivatives.

Statistical Analysis

Data analyses were performed using SPSS version 20. One-way ANOVA was used to test for the presence of significant differences ($p < 0.05$) between varieties in each parameters. Mean, standard deviations, and the range of chemical composition of all varieties was analyzed using SPSS version 20 software.

3. RESULTS AND DISCUSSION

3.1. Proximate composition canola varieties

Results of moisture contents presented in (Table 1) showed significant differences were not observed among the different rapeseed varieties. The maximum moisture content was recorded in "Belinda" (6.35%) variety, while the minimum moisture content was recorded in "Dodgar" (6.03%). The seed moisture content (4-9%) of the total seed weight, which was important for commercial value and storage point of view (Prem et al., 2012). The amount of moisture in the fresh oil seeds varies from 5.50 to 8.50%, which is somewhat similar to our findings (Biswas et al., 2001). The difference moisture contents in seeds may be due to a number of factors including relative humidity and temperature at each stage of production (in the field, at harvest, during storage and during processing) and genetic nature of different cultivars. Moisture can have a significant effect during seed storage and processing. High temperature and moisture can quickly lead to seed spoilage during storage, and anecdotal evidence suggests maintaining moisture at or below 8% during long term storage is beneficial. High moisture contents also interfere with the flaking, pressing and extraction processes, therefore excessive moisture must be removed before those processes can begin.

Table 1. The result of proximate analyzed in canola varieties in Ethiopia (%)

Varieties	MC	Ash	OC	PC	CF	CHO
Axan	6.24 ± 0.30^a	4.16 ± 0.23^b	46.63 ± 0.97^a	20.02 ± 0.16^c	11.13 ± 0.24^a	11.81 ± 1.50^b
Dodgar	6.03 ± 0.21^a	4.10 ± 0.13^b	41.97 ± 0.65^c	22.92 ± 0.48^a	10.38 ± 0.50^b	19.07 ± 2.34^a
Belinda	6.35 ± 0.34^a	4.89 ± 0.24^a	45.04 ± 0.80^b	21.45 ± 1.05^b	11.18 ± 0.30^a	11.06 ± 1.92^b
Mean	6.20 ± 0.28	4.38 ± 0.20	42.83 ± 0.75	21.46 ± 0.56	10.89 ± 0.34	13.98 ± 1.92
C.V. %	2.61	10.03	5.31	6.75	4.11	7.64

Where MC- moisture content, OC- Oil Content, PC- Protein Content , CF- Crude Fiber, CHO- Carbohydrate

The oil content of different varieties of rapeseed varied from 46.63% to 41.97% (Table 1). Rapeseed variety Axan contained highest amount of oil (46.63%), followed by Belinda (45.04%) and Dodgar (41.97%). The results clearly indicated that rapeseed variety can be considered as better source of oil. Present study showed that values of oil content of rapeseed seed were higher than the reported value of Gadei *et al*, (2012) and Moser *et al*. (2009), who found that oil content ranges from 28-32% for mustard seed. However, comparatively similar levels of oil content in seed ranging from 38 to 44 % and 36 to 46 % were reported by Novoseloy *et al.,* (2002) and Si *et al.,* (1997) respectively. On the other hand,

the present investigations were more similar with the reported values of Sengupta *et al.,* (2003) and Mandal *et al*., (2002). Similar oil content (44.3 %) was found by Velasco *et al*., (1998) using NIRS for screening of quality traits in rapeseed. These variations might be due to variation in genotype of diversity and/or environmental influences, soil and crop management practices.

Ash content of different varieties of canola seeds determined and ranged from 4.10% to 4.89% (Table 1). Ash levels can be affected by agronomic conditions, harvest conditions, seed handling and storage. The variety "Belinda" contained highest amount of ash (4.89%) while the lowest amount of ash content (4.10%) showed by "Dodgar" variety i.e. "Belinda" contained the highest amount of ash (4.89%) followed by "Axan" (4.16%) and "Dodgar" (4.10%). Our studies values of rapeseed varieties have more or less similar value with result of mustard Abul-Fadl *et al*., (2011) and significantly higher than Sarker *et al.,* (2015) for mustard seed.

Canola is not only an oilseed crop, but also contains a relatively high protein concentration, due to this reason its meal is used as a protein supplement for animals and possibly will be for humans in the near future. In this study, the highest protein concentration (22.92%) was found in Dodgar and lowest was in Belinda (20.02%) (Table 1). These results are in agreement with the findings of Velasco et al.,(1998), Muhammad *et al.,* (1991) and Özer (2003) who reported the protein value ranging from 13.4-28.3%, 23.8- 25.5% and 18.84-20.05% respectively in fresh seed of Brassica genotypes.

Carbohydrate content of different varieties were determined moisture free basis. Significantly highest amount of carbohydrate contained found in Dodgar (19.07 %) and was significantly highest than other varieties. The lowest amount of carbohydrate was obtained from Belinda (11.06%) which was significantly lowest among all the varieties. Agronomics practices, environmental factors as well as variation among the varieties might be influenced the carbohydrate content (Table 1).

From the same Table, it could be also observed that the tested seeds of rapeseed varieties containing an adequate percentage of crude fiber which were found to be as 11.18, 11.13 and 10.38% in Belinda, Axan and Dodgar respectively.

3.2. Physical properties of oil extracted rapeseeds.

Physical properties of the oil extracted from the seeds were given in (Table 2). The color of the oils slightly varied from Light yellow in Dadgar to Golden yellow in Belinda and Yellow in Axan. The state at room temperature of the oils was generally liquid. The density of the oil relative to that of an equal volume of water (specific gravity) ranged from 0.95 in Dogdar to 0.97 in Axan and Belinda. The value of specific gravity found in the Axan and Belinda were almost higher than Dodgar (Table 2). These values were within the range of other edible oils reported by Onyeike and Acheru, (2002).

Table 2. The result of physical properties of oil extracted rapeseeds.

Varieties	Color	Odor	State at RT^{C}	Refractive index (at 25°C) (nD 40°C)	Specific gravity (at 27°C)
Axan	Yellow	Agreeable	Liquid	1.367 ± 0.09^{a}	0.97 ± 0.01^{a}
Dodgar	Light yellow	Pleasant	Liquid	1.463 ± 0.06^{a}	0.95 ± 0.01a
Belinda	Golden yellow	Agreeable	Liquid	1.447 ± 0.06^{a}	0.97 ± 0.00^{a}
Mean				1.425 ± 0.07	0.96 ± 0.01
C.V. %				3.60	1.19

Refractive index is the ratio of the velocity of light in a vacuum to that in the particular oil. It is regarded as a measure of the purity of the oil. Moreover, refractive index is used mainly to measure the change in unsaturation as the fat or oil is hydrogenated. It depends on their molecular weight, fatty acids chain length, degree of unsaturation and degree of conjugation (Paul, 2013 and Gunstone, 2004). Refractive index for canola oils in the study were obtained 1.367, 1.447

and 1.463 in Axan, Belinda and Dodgar respectively (Table 2) which closely agrees with values suggested for edible vegetable oils such as Neem and sesame oil (Paul, 2013). All Varieties with a high level of polyunsaturated fatty acids, showed the maximum refractive index. This indicates that extracted oils was pure (no adulteration) and therefore minimizes purification procedures during processing such as filter pressing and/or centrifugation.

3.3. Chemical properties of oil extracted from the rapeseeds

Table 3. The Result of chemical properties of oil extracted from the Canola varieties (%)

Varieties	SV mg KOH/g	FFA (%)	AV mg KOH/g	EV mg KOH/g oil	PV (mEq/Kg)	IV (g/100g)
Axan	178.6 ± 5.5[b]	1.12 ±0.04[a]	2.22 ± 0.09[a]	176.40 ± 5.41[b]	5.20 ±0.60[a]	101.36 ± 2.31[a]
Dodgar	182.8 ± 4.5[a]	1.03 ± 0.06[a]	2.05± 0.12[a]	180.47 ± 5.01[a]	5.70 ± 0.55[a]	99.00 ± 2.26[a]
Belinda	175.2 ± 6.2[b]	1.13 ± 0.10[a]	2.24± 0.20[a]	173.02 ± 6.07[b]	4.93 ± 0.75[a]	100.06 ± 4.16[a]
Mean	178.8 ± 5.4	1.09 ± 0.06	2.17 ± 0.13	176.63 ± 5.49	5.27 ± 0.63	100.14 ± 2.91
C.V. %	2.12	5.03	4.81	2.11	7.40	2.18

Where SV- Saponification Value, FFA - Free Fatty Acid, AV - Acid Value, ES - Ester Value, PV - Peroxide Value, IV - Iodine Value

The results of some chemical properties of oils extracted from the canola analyzed were presented in (Table 3). The Saponification value (or "Saponification number") is the number of milligrams of potassium hydroxide required to saponify 1gm of fat under the conditions specified. It is a measure of the average molecular weight of all the fatty acids present. In this study the higher Saponification value indicates high proportion of lower fatty acids since saponification value is inversely proportional to the average molecular weight or chain length of the fatty acids (Muhammad et al., 2011). Therefore, shorter the average chain length the higher is the saponification number (Tamzid et al., 2007). The value obtained for extracted oils during the study show that it contains high amounts of short chain fatty acids, but less than the regulation of codex standard permissibility level (CODEX-STAN210-1999) (189-199mg KOH/g).

Free fatty acid can stimulate oxidative deterioration of oils by enzymatic and/or chemical oxidation to form off-flavour component. The free fatty acid and acid value of the oil extracted from all samples were low which indicate that they probably could be stored for a long time without spoilage through oxidative rancidity and could find application as edible oils. In this study the free fatty acid value were within range i.e., $\leq$ 2 (AOF Standard manual) (2016/17) http://www.australianoilseeds.com. In the tropics, where vegetable are the most common dietary lipids it has been shown that it is desirable that the free fatty acid content of cooking oils lies within limits of 0.0 - 3.0 % Onyeike and Acheru, (2002).

Acid value is an important index of physicochemical properties of oil which is used to indicate the quality age, edibility, and suitability of oil for use in industries. Acid value is used to measure the extent to which glycerides in the oil has been decomposed by lipase and other physical factors such as light and heat. The presence of FFAs in an oil is an indication of insufficient processing, lipase activity, or other hydrolytic actions. The result in (Table 3) showed that acid value of Axan oil 2.22 KOH/g, Dadgar oil 2.05 KOH/g and Belinda oil 2.24 KOH/g respectively. These results indicate that the lower the acid value of oil, the few fatty acid it contains which makes it less exposed to the phenomenon of rancidity.

Peroxide value is useful early indicator of oxidative deterioration and a decrease in the effectiveness of the oil's own antioxidants. During oxidative deterioration the peroxide value first rises and then falls after reaching a maximum value. This leads to difficulties with the interpretation of occasional measurements. During storage, peroxides are generated by oxygen access. The deterioration by oxidation is supported by oxygen access, light and high temperatures and by the presence of metal catalysts (Thuneke and Kern, 2002). Peroxide values of all the oil extracted fall below 10 meq oxygen/kg oil; these values were within the permitted level of not more than 10 mEq peroxide oxygen/kg oil for soybean, cotton seed, rapeseed and coconut oils stipulated by the Code Alimentarius Commission (1982). This depicts that the oils are fresh and could be stored for a long period of time without getting rancid. This is of nutritional interest; it suggests that they could be utilized as edible oils.

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Iodine value is a measure of the degree of unsaturation of oil, which has a strong effect on the physical characteristics of the oil such as the solid fat index. It gives an indication of the degree of unsaturation of a fat or oil. The tendency of an oil to combine with oxygen of the air and become gummy (known as drying) is measured with the iodine number, which in fact is merely a measure of the level of unsaturation of the oil in question (a higher iodine number will indicate higher unsaturation seeing that iodine is absorbed primarily by the mechanism of addition to the double bonds characteristic of unsaturation) (Gertz, 2000). The result in (Table 3) shows that the iodine value of oils were with the highest mean iodine number 101.36 in Axan followed by 100.06 in Belinda and 99.00 in Dodgar oils. The iodine value in all samples were high means the fatty acids in this fat is less saturated. The physical state of oils extracted was liquid at room temperature because the majority of the fatty acids in the triglyceride bond are in unsaturated form. manufacturers and food service providers use the iodine value as a quick indication of the suitability of an oil for their needs, therefore this is a very useful tool.

4. FATTY ACIDS COMPOSITION OF CANOLA VARIETIES

Table 4. Fatty acid composition (w/w %) of oil from different canola oil cultivars.

Fatty Acid	Axana	Dodgar	Bilenda
C14:0	0.57 ± 0.08^{ab}	0.42 ± 0.03^{b}	0.65 ± 0.09^{a}
C16:0	4.18 ± 0.24^{a}	3.90 ± 0.31^{a}	4.19 ± 0.20^{a}
C18:0	2.47 ± 0.04^{b}	2.92 ± 0.22^{a}	2.71 ± 0.27^{ab}
C20:0	1.51 ± 0.03^{ab}	1.36 ± 0.05^{b}	1.65 ± 0.16^{a}
SFA	8.74 ± 0.31^{a}	8.60 ± 0.49^{a}	9.20 ± 0.44^{a}
C16:1	0.52 ± 0.02^{a}	0.56 ± 0.05^{a}	0.53 ± 0.05^{a}
C18:1	62.10 ± 1.97^{a}	62.11 ± 0.60^{a}	61.48 ± 0.73^{a}
C20:1	1.12 ± 0.04^{a}	1.08 ± 0.04^{a}	1.16 ± 0.08^{a}
C22:1	0.70 ± 0.07^{a}	0.78 ± 0.07^{a}	0.56 ± 0.02^{b}
MUFA	64.43 ± 2.01^{a}	64.53 ± 0.56^{a}	63.73 ± 0.72^{a}
C18:2	18.45 ± 1.11^{a}	18.77 ± 1.08^{a}	18.38 ± 0.68^{a}
C18:3	8.37 ± 0.71^{a}	8.05 ± 0.30^{a}	8.68 ± 0.50^{a}
PUFA	26.82 ± 1.81^{a}	26.51 ± 0.97^{a}	27.06 ± 1.04^{a}
USFA	91.26 ± 0.35^{a}	91.04 ± 0.56^{a}	90.69 ± 0.48^{a}
PUFA/SFA	3.07	3.08	2.94

SFA: Saturated Fatty Acids; MUFA: Monounsaturated Fatty Acids; PUFA: Polyunsaturated Fatty Acids; UNSFA: Unsaturated Fatty Acids,

[a] Values Followed by different letters in each row are significantly different ($P < 0.05$).

The fatty acids profile of the oil extracted from three canola varieties was presented in (Table 5). The main constituents of canola oil are saturated fatty acids (C14:0, C16:0, C18:0 and C20:0), mono-unsaturated fatty acids (C16:1, C18:1, C20:1 and C22:1) and poly unsaturated fatty acids (C18:2 and C18:3). The result showed that palmitic acid was the major saturated fatty acid in all three varieties and all varieties contain almost similar result but highest level was found in Bilenda variety. This result showed all varieties have similar level of total saturated fatty acids ($P < 0.05$). The unsaturated fatty acids were predominant in all varieties. However, oleic acid was the major fatty acid in all three varieties and its content ranged from 61.48 to 62.11%. The highest level of oleic acid was found in Dodgar variety. The range of oleic acid in canola cultivars has been reported to be between 51 and 70% (Codex Alimentarius Commission, 2001). Among these varieties, Dodgar showed the highest level of total monounsaturated fatty acids (64.53%), whereas the highest level of total polyunsaturated fatty acids was observed in Belinda variety (27.06 %). The highest level of essential fatty acids, including linoleic acid (18.77 %) and linolenic acid (8.68 %) were found in Dodgar and Belinda varieties, respectively. The content of linoleic acid in canola ranges between 15.0 and 30.0% (Codex Alimentarius Commission, 2001). In all three varieties, C22:1 acid content was low and within the permitted level (maximum 2%) and the lowest level (0. 56 %)

was found in Bilenda variety. The PUFA/SFA ratio of analyzed oil samples was in the ranges of 2.94 (Belinda) – 3.08 (Dodgar) which shows a good agreement with the FAO/WHO recommendation standards to be greater than 0.4. From this study it should be noted, the seeds of all three varieties had similar (but not identical) fatty acid compositions and contained low amounts of saturated fatty acids.

5. CONCLUSION AND RECOMMENDATION

The study has information on the proximate composition of 3 Ethiopian canola varieties and Physico-chemical properties of oil extracted. Proximate composition such as moisture, ash, crude fat, crude fiber, crude protein and total carbohydrates canola varieties were found with the average value of 6.20 %, 4.38 %, 42.83 %, 10.89 %, 21.46 %, and 13.98 % respectively. The oils extracted was characterized by investigating Physico-chemical parameters and results show that the extracted oils was liquid at room temperature, have average density (0.95-0.97), Refractive index (1.367-1.447), acid value (2.05-2.24), saponification value (175.2-182.8), iodine value (99.00-101.36), peroxide value (4.93 - 5.70). The varieties generally showed an appreciable amount of all the omega fatty acids (omega-3,-6, -9) but is specifically rich in omega-9 fatty acid with 61.48 to 62.11% oleic acid and unsaturated fatty acids with PUFA/SFA ratio between in the ranges of 2.94 (Belinda) – 3.08 (Dodgar) which in general, meets the requirement set by WHO/FAO to be greater than 0.4. This result of analysis confirms the standard specification and reveals that the extracted oil has good quality for consumption as well as industrial purposes and commercial applications.

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