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PHYSICOCHEMICAL AND NUTRITIONAL CHARACTERIZATION OF LINSEED (*Linum usitatissimum* L.) OIL BY DIFFERENT METHODS

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ABSTRACT
Physicochemical and nutritional quality of mechanically (ME) and solvent extracted (SE) linseed oil was evaluated. SE exhibited higher yield of oil (46.16%) than ME (29.75%). A trivial variation noticed in physicochemical characteristics of linseed oils produced by both the methods. The fatty acid profile of SE and ME oils showed considerable variation in oleic and linoleic acid. ME oil has higher total tocopherol (113.90 mg kg-1) as compared to SE oil (70.90 mg kg-1). According to results, ME oil founds nutritionally predominant over SE oil which may be ascribed to the mild extraction conditions utilized amid Mechanical Extraction.

KEY WORDS: Mechanical Extraction, Solvent Extraction, Linseed oil, Tocopherol.

INTRODUCTION

Linum usitatissimum L. also known as flaxseed is one of important oil and fiber rich oil crop. Canada is the leading linseed producer, followed by China, United States and India (Rubilar *et al*., 2010). Flaxseed utilization in different forms as a food ingredient and its therapeutic properties since it is a main wellspring of the omega-3 fatty acid α-linolenic acid (ALA) (52% of total fatty acids) and phenolic compounds known as lignans (>500µg1, basis) (Oomah and Mazza, 2000). Flaxseed oil, rich in PUFA have a positive impact on human health, helps in prevention of cardiovascular diseases (Hasler 1998; Zhao *et al*., 2004). Health benefits of n-3 PUFA are related to incorporation of fatty acids into membrane phospholipids, alteration of gene expression, or eicosanoid production (Abayasekara and Wathes, 1999). A human body enzyme converts Omega 3 fatty acids into the higher fatty acids (EPA, DHA) through a series of reaction. DHA not only protect against Alzheimer's disease but also it is important during pregnancy in (Cheatham *et al*., 2006; Innis, 2007).

Seed oil can be extracted by solvent or expeller press (mechanical) on an industrial level. The *n*-hexane or petroleum ether is very common as extraction solvent. The higher temperature in the solvent extraction process may leads to the undesirable effects on the quality of oil (Febrianto *et al*., 2012). Despite the lower oil yield, Mechanical extraction is advantageous over Solvent extraction in respect to mild operational temperature conditions, process safety and product quality (Bavec *et al*., 2007).

In a view of the high demand and consciousness about the consumption of functional, nutritional and healthy oil, the present study was undertaken with the main objective to assess and compare the physicochemical property and nutritional quality of mechanically and solvent extracted linseed oil.

MATERIALS AND METHODS

Raw materials and chemicals

All the raw material was procured from the local market. All the chemicals and glassware's used in present investigation were of analytical grade and were obtained from the Department of Food Chemistry, College of Food Technology, VNMKV, Parbhani (MS), India.

Extraction of linseed oil

The oil from the linseeds was extracted through mechanical extraction. The solvent extraction was done by method as described in (AOAC, 2002) using food grade hexane as solvent. The traces of hexane were removed using rotary flash evaporator. The mechanical extraction was carried out by screw press; the recovered oil was decanted and weighed. The extracted oil was stored in dark place at room temperature. The oil extracted was assessed for different physical and chemical parameters. Extracted oil was used for the further study.

Physico-chemical Characteristics of oils

Colour (L*, a*, b* values) of the oil was determined by using Hunter Colour Flex Meter[14]. Refractive index was determined as method described by Pearson (1976). The specific gravity was expressed in terms of ratio of density of oil to water. A Brookfield Viscometer Model DV-E was used to measure the viscosity of extracted oil (Bhavsar *et al*., 2017). Viscosity was determined to at constant speed of 100 rpm and at constant temperature with a spindle number S-62 and it was expressed in terms of (cP). The chemical properties such as the iodine value (IV), acid value (AV), Peroxide value (PV), saponification value (SV), and free fatty acids (FFA) of the extracted oils were analyzed according to AOAC standard methods (Popa *et al*., 2012).

Fatty Acid Profile of linseed oil

Fatty Acid Profile of oil was determined using Gas chromatography of FAMEs (Fatty Acid Methyl Esters)

with Flame Ionization Detector by AOCS Official Method Ce 1h-05 (AOCS, 2005)..

Total Tocopherol

The quantification of tocopherol content of linseed oil was performed by using HPLC method (Hatman and Kayden, 1979) using a Agilent 1100 Series HPLC system equipped with a fluorescence detector and Phenominix C18, column (250×4.60 mm, 5µm particle size).

RESULTS AND DISCUSSION

Physical properties of extracted oil

The physical properties such as colour, refractive index, specific gravity are determined and represented in Table-1. The oil yield of solvent extraction was more as compared to mechanical extraction. The linseed shows the oil yield of *i.e.* 29.75% and 40.16% by mechanical and solvent method respectively. Similar results were reported earlier (Mariod *et al*., 2012; Nadeem *et al*., 2015).

Colour is also one of physical property which determines the adulteration of oil or fat. The physical properties of linseed oil has colour values such as L* value (50.95), (52.51), a* value (-2.009), (-0.93) and b* value (42.98), (46.49) for mechanically extraction and solvent extracted oil respectively.

There was very negligible difference observed in case of refractive index and specific gravity of mechanical and solvent extracted oil. Refractive Index is the process of measuring the change in unsaturation of fat or oil on hydrogenated. The refractive index of oils depends on their molecular weight, fatty acids chain length, degree of unsaturation and degree of conjugation (Andhale *et al*., 2017).

TABLE 1: Percent yield and Physical Properties of linseed oil extracted by different methods

Parameters		Extraction Method	
		ME*	SE**
Total Yield (%)		29.75	40.16
Colour	L	50.95	52.51
	a*	-2.009	-0.93
	b*	42.98	46.49
Refractive Index (Abbes, 27^0C)		1.4746	1.4739
Specific gravity (mg/ml)		0.926	0.925
Viscosity (cp)		52.5	27.9

ME*- mechanical extracted; SE**- solvent extracted
*each value is average of three determinations

It is revealed that the viscosity values for mechanical extracted oil 52.5 (cP) was higher than solvent extracted oil 27.9 (cP) at 25^0C, this might be due to the dissolved solids and impurities in mechanical extracted oil.

Chemical properties of extracted oil

The chemical properties such as acid value, iodine value, peroxide value, saponification value and free fatty acid are studied and represented in Table-2.

Iodine values give an estimation of the amount of unsaturated fatty acids in the triglyceride molecules of fat and oil (Bhavsar *et al*., 2017). It was observed from Table-2 that the Iodine value (IV) of mechanically extracted linseed oil was 170 g of I_2/100g of oil whereas IV for solvent extracted linseed oil was 168 g of I_2/100g of oil. The IV of extracted oils agreed with previous reports (Popa *et al*., 2012). The Acid value which is a measure of the free fatty acids in oil was found to be 2.96 and 3.58 mg KOH/g of oil for mechanically and solvent extracted linseed oil respectively. The results of acid value are in accordance with (IS-75, 1973).

TABLE 2: Chemical properties of linseed oil extracted by different methods

Parameters		Extraction Method	
		ME*	SE**
Iodine value	(mg I/100g)	170	168
Acid value	(mg KOH/g)	2.96	3.58
Peroxide value	(meq O_2/kg)	2.13	4.28
Saponification value	(KOH/g)	192.4	189.0
Free fatty acid (as oleic acid %)	(g/100g)	1.49	1.80

ME*- mechanical extracted; SE**- solvent extracted
*each value is average of three determinations.

Peroxide value (PV) is a measure of oxidation during storage and the freshness of lipid matrix (Atinafu *et al*., 2011). The PV for mechanically extracted and solvent extracted linseed oil was 2.13 and 4.28g of meqO_2/kg oil respectively. It revealed that the mechanical extraction is better for yielding good quality oil due to mild operational conditions (Bhatnagar and Gopala Krishna, 2014). The results of peroxide value were in accordance with (IS-75, 1973). Saponification value (SV) is an indication of the molecular weights of triglycerides in oil (Muhammad *et al*., 2011). The results showed that SV of 192.4 and 189.0 KOH/g of oil for mechanically extracted and solvent extracted linseed oil. The SV of the oils agreed well with the literature (Borhade, 2014).

The value obtained for free fatty acids (FFA) was 1.49 and 1.80g/100g of oil for mechanically extracted and solvent

extracted linseed oil respectively. The FFA of the oils agreed well with previous findings (Kasote *et al*., 2013). The FFA content was higher in solvent extracted oil because FFA is readily soluble in polar solvents (Bhatnagar and Gopala Krishna, 2014).

Fatty acid profile and total tocopherol of extracted oil

The data pertaining to fatty acid and total tocopherol content of extracted oil are given in Table-3. Overall, there was marginal difference observed for the fatty acid composition of the extracted oil obtained by mechanical and solvent extraction method. It was observed from present finding that among the saturated fatty acids the stearic acid concentration was found to be higher as compared to the other saturated fatty acid followed by the palmitic acid. The stearic acid concentration was 6.69 and 6.82% in case of mechanically and solvent extracted linseed oil respectively. The findings of present experiment were more or less similar to that of the earlier results (Gutierrez *et al*., 2013).

In mono-unsaturated fatty acids, oleic acid concentration was found to be predominant. The oleic acid concentration was found to be 21.18 and 21.65% in case of mechanically and solvent extracted linseed oil respectively. The present findings regarding the mono-unsaturated fatty acid were almost comparable with the concentration reported earlier (Gutierrez *et al*., 2013).

TABLE 3: Fatty acid profile and total tocopherol of linseed oil extracted by different method

Fatty Acids	Extraction Method	
	ME*	SE**
Saturated	Concentration in Percent	
Palmitic acid	6.47	6.45
Stearic acid	6.69	6.82
Behenic acid	0.24	ND
Lignoceric acid	ND	0.16
Unsaturated		
Monounsaturated		
Palmitoleic acid	ND	0.07
Oleic acid	21.18	21.65
Eicosenoic acid	ND	ND
Polyunsaturated		
Linoleic acid	13.51	13.50
Gamma linolenic acid	0.20	0.22
Alpha linolenic acid	51.71	51.05
Total Tocopherol (mg/100g)	113.90	74.69

ME*- mechanical extracted; SE**- solvent extracted; ND- not detected
*Each value is average of three determinations

In regards of polyunsaturated fatty acids alpha linolenic acid (C18:3n3) was predominant in linseed oil. The linseed oil showed an alpha linolenic acid concentration of 51.71 and 51.05% for mechanically and solvent extracted linseed oil. Linseed extracted by mechanical and solvent method shows a concentration of 13.51 and 13.50% linoleic acid respectively. The present findings were more or less similar (Bozan and Tamelli, 2008).

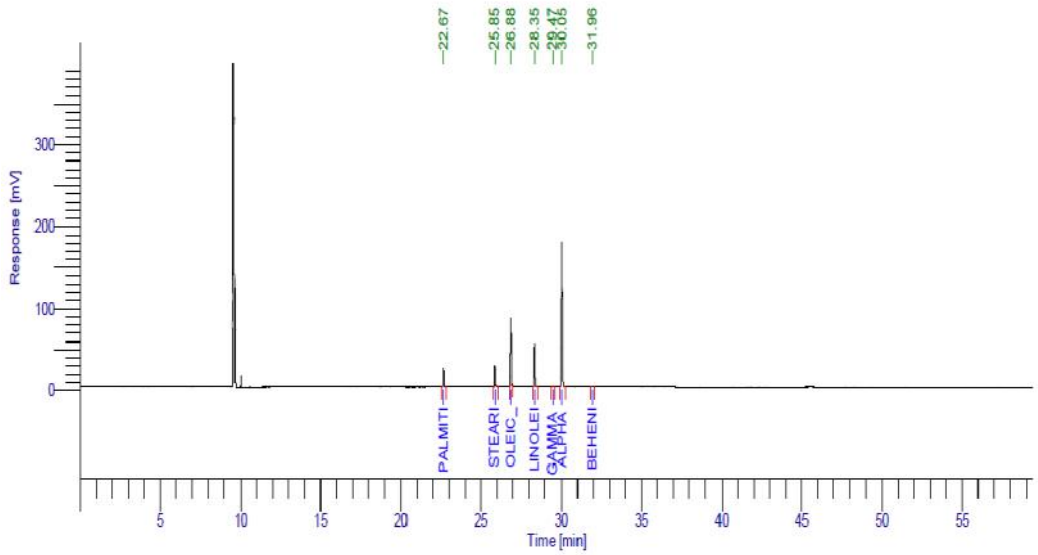

FIGURE 1: Fatty acids chromatogram of mechanically extracted linseed oil

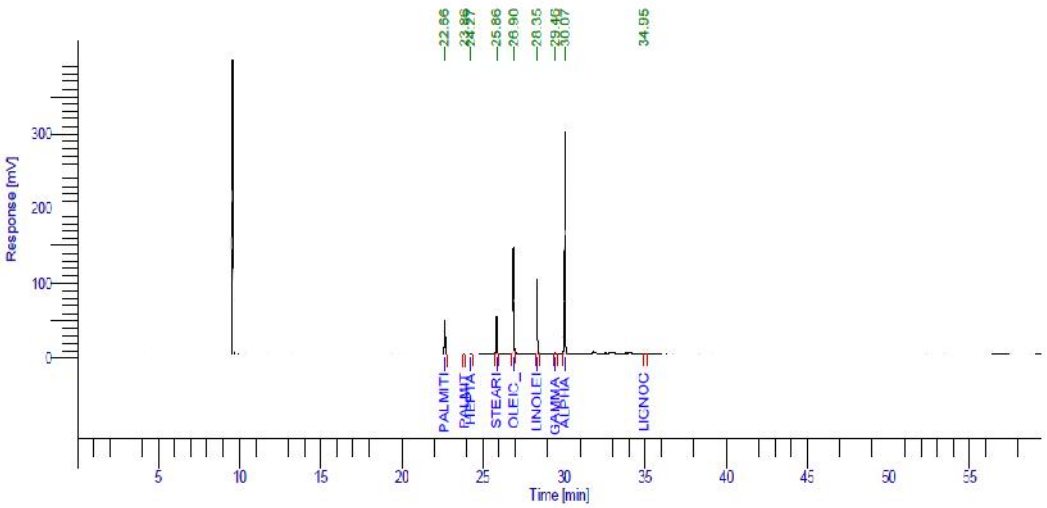

FIGURE 2: Fatty acids chromatogram of solvent extracted linseed oil

The highest tocopherol content was found in mechanically extracted linseed oil. The total tocopherol content of mechanically and solvent extracted linseed oil was 113.90 and 70.90 mg/100g of oil respectively. The lower value of total tocopherol for solvent extracted linseed oil is resulted due to use of high temperature during solvent extraction which was much higher than that of mechanical extraction. The results were in line with earlier findings (Bozan and Tamelli, 2008; Bhavsar *et al*., 2017).

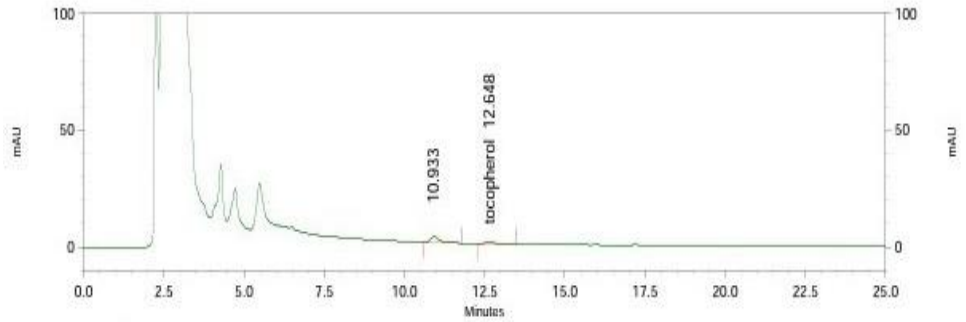

FIGURE 3: Chromatogram of tocopherol of mechanically extracted linseed oil

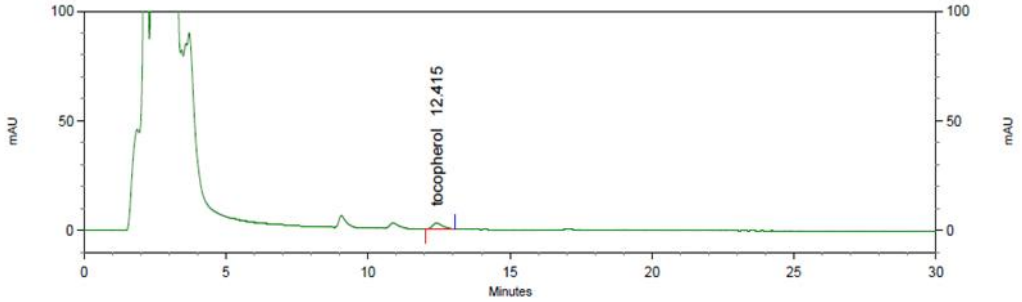

FIGURE 4: Chromatogram of tocopherol of solvent extracted linseed oil

CONCLUSION

Due to lower peroxide value and higher total tocopherol content, high stability and superior quality linseed oil was extracted by mechanical extraction method. Although the mechanical extraction gives lower yield, is advantageous with regard to mild operational temperature conditions, process safety and product quality.

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