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COMPARATIVE STUDY ON CHARACTERISTICS OF SEED OIL AND NUTRITIONAL COMPOSITION OF SEED CAKE IN DIFFERENT TOBACCO TYPES CULTIVATED IN INDIA

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Alternative uses of tobacco gained importance in recent times to sustain the crop for non-conventional and economically viable application in food and industries. One of the alternative promising uses of tobacco is seed oil having nutritive, pharmaceutical and industrial utility. Solvent extraction of seven types of tobacco seeds [(Siri (FCV), GT-7 (*bidi*), Manasi (Jati tobacco), Dharla (Motihari tobacco), HDBRG (burley type), Banket A1 (burley) and Abirami (chewing type)] yielded the oil content ranging from 32.79 to 38.14%. The variety HDBRG contained maximum oil content (38.14%) followed by *bidi* tobacco variety GT-7(37.70%). Quality characters *viz.*, saponification value, iodine value, peroxide value and acid value varied among the tobacco seed oils. The predominant fatty acids were palmitic, stearic, oleic and linoleic acids. Oleic and linoleic acids contents ranged from 9.22 to 13.60% and 72.49 to 79.07%, respectively among the tobacco seed oils. The important feature of tobacco seed oil was that it also contained 1.30% of linolenic acid which is an essential fatty acid. Tobacco seed oil has a higher ratio of polyunsaturated to saturated fatty acids than sunflower and groundnut oils and comes under class 1 of nutrition classes of edible oils. Total protein content varied from 27 to 32.12% among the de-oiled seed cakes. Among soluble proteins, globulins were the major fraction followed by albumins, glutilins and prolamins. Total carbohydrates content varied from 7.50 to 10.24% while total nitrogen varied from 4.32 to 5.14% in the seed cakes. From the quality point of view, tobacco seed oil is comparable to other edible oils and can be utilized in food and industries. De-oiled tobacco seed cake is rich in nitrogen (around 5%) and could serve as animal feed supplement. The results show considerable variability in quantity and quality of oil among the varieties/ types which may be attributed to genetic variability and helpful for selection of varieties.

Key words: Biochemical characters, De-oiled cake, Seed oil, Tobacco

INTRODUCTION

Tobacco is a leading commercial crop in India and is grown in 0.45 million ha of area with 750 million kg leaf production. Different types of tobacco *viz.*, flue-cured Virginia (FCV), burley, *bidi*, *natu*, cheroot, hookah, cigar-wrapper, cigar-filler and chewing are being cultivated under different agro-climatic conditions in India. However, the anti-tobacco campaign for traditional form of consumption is posing a serious challenge to tobacco production, trade and industry. The economic life of millions of people, including six million farmers, depends on tobacco necessitating the crop to be sustained for its potential alternative uses. The promising alternative uses of tobacco is seed oil having nutritive, pharmaceutical and industrial uses (Awolola *et al.*, 2010). The research on alternative uses of tobacco is the order of the day, leading to critical examination of potentials of tobacco as 'an oil seed crop'. An estimated 1300-1500 tonnes of tobacco seed oil is expelled and exported from India to other countries for utilization in paint industry (Deo Singh and Narasimha Rao, 2005). It is used as raw material in coating industries, preparation of printing inks, dyes (Zlatanov *et al.*, 2007), production of soaps, shoe polish, varnishes (Purseglove, 1991), an alternative to diesel fuel (Giannelos *et al.*, 2002) and potential use in food and coating industries (Mukhtar *et al.*, 2007). However, the tobacco seed oil is not being used for edible purpose in India, but finds extensive use in paints, varnishes, lubricants and soap industries. The demand for edible oils in India has shown a growth rate of 4.43% from 2001 to 2011. There has been a significant gap between demand and supply of edible oil because of limited oil seeds and shifting of acreage to other crops, thus making need to search for alternative sources of edible oils.

The tobacco seed contains on an average of 35% oil and linoleic acid is the major fatty acid

(66 – 76%) (Siva Raju *et al.,* 2011). Tobacco seed oil, as reported by earlier workers (Frega *et al.*, 1991; Patel *et al.*, 1998; Zlatanov *et al.*, 2007; Abbas Ali *et al.*, 2008) shows a wide variation in its fatty acid composition depending on the verities, climatic condition under which plants aregrown. Tobacco seed oil shows promise as edible oil due to demonstration of the dietary effect of linoleic acid rich oils like corn or safflower oils in lowering the serum cholesterol (Senugupta and Mazumder, 1976). To promote tobacco as an oil seed crop, detailed research on chemical and biochemical characterization of tobacco seed oil, nutritional quality evaluation of tobacco seed oil for edible purpose and identification of tobacco genotypes with high seed and oil yield potential with better oil quality is needed. In the present paper the chemical and biochemical characters of seed oil in different tobacco types grown in India are reported.

MATERIALS AND METHODS

Seeds of different tobacco types were obtained from CTRI Research Stations. Except the variety Dharla, all the other belonged to the species *Nicotiana tabacum* L. The types of tobacco used in the present studies were Siri (flue-cured Virginia), GT-7 (*bidi*), Manasi (Jati), Dharla (Motihari, *Nicotiana rustica*), HDBRG (burley type), Banket A1 (burley) and Abirami (chewing).

Oil content of tobacco seeds was estimated by Soxhlet method (Sadasivam and Manikam, 1992). Five grams of seed was pounded well using mortar and pestle and packed into Whatman thimble . A piece cotton was placed at the top to evenly distribute the solvent as it drops on the sample during extraction. The thimbles were placed in the butt tubes of the Soxhlet extraction apparatus. The extraction was done with 150 ml of hexane for 8 h by gentle heating. After extraction, the flasks were cooled and hexane was removed using flash evaporator (vacuum evaporator). The flasks were dried in the oven to remove traces of hexane at 70°C and were cooled in the desiccator and weighed. This was repeated till the constant weight of oil was obtained. Values were expressed as per cent.

Tobacco seed oil was analyzed for acid value (Sadasivam and Manikam, 1992), peroxide value (Cox and Pearson, 1962), iodine value and saponification (William Horowitz, 1975). Individual free fatty acids were estimated by GC-MS after esterification of fatty acids by sulphuric acid in methanol (Sadasivam and Manikam, 1992). The analysis was carried out using a ZB-5 capillary column (length: 30 m, diameter: 0.25 mm, film thickness: 0.25 µm) fixed in a Shimadzu QP 2001 Plus GC-MS with the following temperature programme; column 180°C for 5 min, 5°C/min to 220°C and for 17 min; injector temp 250°C and interface temperature 250°C. The methyl esters were identified and calculated by comparison of retention times of the oil components with those of standard methyl esters. The samples were injected maintaining a split ratio of 1:50. De-oiled seed cakes were dried, powdered and analyzed for chemical quality parameters viz., reducing sugars (Harvey *et al.*, 1969), polyphenols (Sheen and Celvert, 1969), starch and total carbohydrates (Sadasivam and Manikam, 1992), soluble proteins (Lowry *et al.*, 1951) and protein fractionation based on solubility criteria (Abdel-Aal *et al.*, 1997). Crude proteins were obtained by multiplying the total nitrogen with factor 6.25. Inorganic constituents *viz.*, chlorides (Hanumantharao *et al.*, 1980), phosphorus, potassium, calcium, magnesium (Jackson, 1967), sulphur (Tandon, 1993) and total nitrogen by auto-analyzer (TIM, 1977) were estimated in seed cakes. For mineral composition, the mean value of two replications was given. The data were statistically analyzed (Panse and Sukhatme, 1957).

RESULTS AND DISCUSSION

Oil content and biochemical characteristics of tobacco seed oil

Solvent extraction of seven types of tobacco seeds yielded oil content ranging from 32.79 to 38.14% (Table 1). The variety HDBRG contained maximum oil content (38.14%) followed by *bidi* tobacco variety GT-7(37.70%). The oil content of the varieties GT-7, Siri and HDBRG was at a par and significantly higher than the varieties Manasi, Dharla and Banket A1. The per cent of oil observed in the present studies was higher than the average of 29.82% reported in three varieties of tobacco grown in Bangladesh (Abbas Ali *et al.*, 2008) and similar to the tobacco varieties grown in Egypt (33.6 to 39.4%) (EL-Hamid *et al.*,

1982). The moisture content among the seeds varied from 4.55 to 7.28% (Table 1). The variety Dharla showed maximum moisture content followed by Manasi whereas it was minimum in the variety Siri. Moisture content is important in the preservation of seeds for a long time to minimize the probability of the bacterial and fungal agents that alter the quality through decomposition. The moisture content around 4% was considered satisfactory for the preservation of tobacco seeds.

Saponification value (SV) varied from 186.36 to 208.60 (mg KOH/g) in tobacco seed oil (Table 1). The variety Siri showed maximum and significantly higher SV (208.60 mg KOH/g) followed by HDBRG (201.3 mg KOH/g) as compared to the other varieties. The variety Dharla showed significantly lower SV (186.36 mg KOH/g) with the exception of Banket A1 when compared to seed oils of other tobacco types. The iodine value (IV) of tobacco seed oils varied from 134 to 138.7 g iodine/100 g oil (Table 1). The IV was significantly higher in the variety GT-7 (138.7 g iodine/100 g) compared to other varieties and at a par with the variety HDBRG (136.8 g iodine/100 g). The IV of other varieties was at a par. The high IV indicates the higher content of unsaturated fatty acids. Saponification values observed in the present study were higher than the reported for different tobacco types (185 -189 mg KOH/g) whereas iodine values were similar to the values reported (134 to 138 g iodine/100 g oil) for different tobacco varieties (Frega *et al.*, 1991; Abbas Ali *et al.*, 2008). The high degree of unsaturation suggests that tobacco seed oil may be used for manufacture of cosmetics, oil paints and varnishes. It may also be used as edible oil for cooking or manufacture of margarines. In general IV is useful for the identification of oils compared to saponification value. The acid value varied from 2.36 to 7. 62 (mg KOH/g oil) among the seven types of tobacco seed oils (Table 1). The acid value was maximum and significantly higher in the oil of variety Abirami followed by Dharla. The content of free fatty acids is directly proportional to the acid value. Ivana Stanisavljevic *et al.* (2007) reported higher acid value (37 mg KOH/g oil) for tobacco seed oil of variety Otlja. The acid value of the oil depends on the maturity of the seeds and longevity of storage and storage conditions.

The oil extracted from seven types of tobacco seeds showed peroxide value (PV) ranging from 1.10 to 2.06 meq/kg (Table 1). The PV of the varieties Dharla, Manasi and HDBRG was significantly higher than the other types of tobacco. Fresh oils usually have PV below 10 meq/kg. A rancid taste begins to develop when the peroxide value in between 20 to 40 meq/kg. Low PV obtained in the present studies indicates that the tobacco seed oil is of good quality. Peroxide value reported by earlier workers for tobacco seed oil varied from 1.77 to 2.56 meq/kg among the different varieties (EL-Hamid *et al.*, 1982; Abbas Ali *et al.*, 2008).

Table 1: Quality parameters of seed oil of different tobacco types

Tobacco variety	Moisture (%)	Oil (%)	Saponification value (mg KOH/g)	Acid value (meq/g)	Peroxide value (meq/kg)	Iodine value (g iodine/ 100 g oil)
GT-7	5.75	37.70	195.8	3.56	1.58	138.7
Abirami	6.22	34.26	192.3	7.62	1.98	134.6
Dharla	7.28	33.44	186.3	5.24	2.06	134.0
Manasi	6.85	32.79	192.4	4.26	2.00	135.4
Banket A1	5.28	34.88	189.3	2.98	1.66	134.8
Siri	4.55	36.86	208.6	2.36	1.10	135.0
HDBRG	5.58	38.14	201.3	3.22	1.91	136.8
SEm±	**0.246**	**0.72**	**1.318**	**0.235**	**0.057**	**0.625**
CD (P=0.05)	**0.81**	**2.20**	**4.05**	**0.720**	**0.175**	**2.20**

Fatty acid composition of tobacco seed oil

Tobacco seed oil contained both saturated and unsaturated fatty acids ranging from C16:0 to C18:3. The predominant fatty acids were palmitic, stearic, oleic and linoleic acids (Table 2). The content of stearic acid and palmitic acid ranged from 2.54 to 3.60% and 5.47 to 8.11%, respectively among the oil samples of different tobacco types. The palmitic acid content was at a par in the oils of variety Manasi and GT-7 whereas they were significantly higher than other oils. There was non- significant variation in stearic acid content among the seven types of tobacco seed oils. The content of oleic and linoleic acids ranged from 9.22 to 13.60% and 72.49 to 79.07%, respectively. Oleic acid content was maximum in the variety Siri and significantly higher than other oils. Oleic acid content was at a par among the oils of varieties Manasi, GT-7, HDBRG and Abirami, and significantly higher than the varieties Dharala and Banket A1. Linoleic acid content was maximum among the fatty acids and the variety Dharla showed significantly higher content of linoleic acid compared to other tobacco seed oils. Linoleic acid content was at a par among the oils of GT-7, HDBRG, Abirami and Siri, and significantly higher than the varieties Manasi and Banket A1. Linolenic acid (1.3%) was observed in the oil of variety Siri, which is an essential fatty acid for human body. The fatty acid composition reported in the present study was similar to the trends with the earlier reported in tobacco seed oils and the major fatty acid was linoleic acid (EL-Hamid *et al.*, 1982; Frega *et al.*, 1991; Zlatanov *et al.*, 2007; Ivana Stanisavljevic *et al.*, 2007; Abbas Ali *et al.*, 2008).

Comparison of tobacco seed oil with other edible oils

Saturated, monounsaturated and polyunsaturated fatty acids content obtained in the tobacco seed oil was compared with sunflower and groundnut oils. Saturated fatty acid content varied from 8.22 to 10.80% among the tobacco seed oils (Table 3). Maximum content of saturated fatty acids were found in the variety Manasi followed by GT-7 and HDBRG whereas the lowest in the variety Abirami. The saturated fatty acid content in tobacco seed oil (10.80%) was less than that of sunflower oil (12%) and groundnut oil (14%). Monounsaturated fatty acids ranged from 9.22 to 13.06% among the tobacco oils and its content in sunflower (24%) and groundnut oils (60%) were 1.83 and 4.5 times higher than the tobacco seed oil respectively. Polyunsaturated fatty acids ranged from 72.84 to 79.07% among the tobacco seed oils. The oil of variety Dharla showed maximum content of polyunsaturated fatty acids whereas it was minimum in oil of variety Manasi. Tobacco seed oil showed 73.4 and 17.5% of higher unsaturated fatty acids compared to groundnut and sunflower oils, respectively. Polyunsaturated fatty acids are very important for human nutrition and especially linoleic acid is an essential fatty acid. The fatty acid composition indicated that tobacco seed oil contained mainly unsaturated fatty acids ranging from 82.38 to 89.00% showing a higher nutritional value and industrial

Table 2: Fatty acid composition of seed oil of different tobacco types

Tobacco variety	Palmitic acid(%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Linolenic acid (%)
Dharla	7.18	2.62	9.97	79.07	-
Manasi	8.10	2.70	11.68	72.49	-
GT-7	8.11	2.54	11.16	75.79	-
HDBRG	7.83	2.59	10.85	75.65	-
Abirami	5.47	2.75	11.43	75.11	-
Banket A1	6.66	2.72	9.22	73.16	-
Siri	6.05	3.06	13.60	75.30	1.3
SEm±	**0.098**	**0.143**	**0.300**	**0.620**	
CD (P=0.05)	**0.301**	**NS**	**0.921**	**1.901**	

applications. Earlier workers reported that the saturated and unsaturated fatty acid composition of tobacco seed oil varied from 11-14% to 82- 86%, respectively among the different tobacco varieties and species (Zlatanov *et al.*, 2007; Ivana Stanisavljevic *et al.*, 2007; Abbas Ali *et al.*, 2008).

From the nutritional point of view, the tobacco seed oil is of superior quality due to higher content of linoleic acid. The nutritional value of edible oil can be appreciated by the ratio between the polyunsaturated to saturated fatty acids. It is considered that a high quality oil has a ratio more than 2. According to the nutritional classification of oils (Zdremtan and Zdremtan, 2006), edible fats are classified into 3 classes. Class 1 – most valuble fats from nutritional point of view, having the ratio more than 2. From the present studies, tobacco oil has a higher ratio of polyunsaturated to saturated fatty acids than sunflower and groundnut oils (Table 3).

Characterization of tobacco seed de-oiled cake (TSC)

The de-oiled tobacco seed cake was analyzed for its chemical and biochemical composition to study its suitability for stock feed. Total protein content varied from 27 to 32.12% among TSCs (Table 4). The seed cake of the variety Manasi showed significantly lower levels of total protein content compared to other TSC. Total protein content of TSC of varieties GT-7, Abirami, Dharla, Siri and HDBRG were at a par. The total protein content in tobacco seed cake was higher than the sunflower cake (20 to 30%) (Frega *et al.*, 1991; Zilic *et al.*, 2010) whereas it was less than groundnut cake (42%) (Fekria *et al.*, 2012). Soluble protein content varied from 16.09 to 20. 47% among the TSCs. The soluble protein content of TSC was at a par among the varieties Dharla, Banket A1 and Siri, and significantly higher than other varieties. Earlier studies reported a variation of 19.2% to 25.9% in total protein content among the TSC (Frega *et al.*, 1991; Abbas Ali *et al.*, 2008).

Total carbohydrates content varied from 7.50 to 10.24% in TSC (Table 4). The total carbohydrates was at a par in the cakes of varieties GT-7, Abirami and Dharla, and significantly higher than other varieties. Starch content varied from 1.49 to 3.64% among the TSCs. The variety Manasi showed significantly higher content of starch than the other varieties whereas it was significantly lower in the variety GT-7. The starch and total carbohydrate contents varied from 4.0 to 4.66% and 9.59 to 12.98%, respectively among tobacco varieties (Abbas Ali *et al.*, 2008). The total carbohydrates content in the tobacco cake was comparable to that of groundnut and sunflower cake (Zilic *et al.*, 2010; Fekria *et al.*, 2012).

Reducing sugar content varied from 0.56 to 0.91% in the TSC. Reducing sugar content was at a par in seed cakes of GT-7, Manasi, Banket A1 and HDBRG whereas it was at a par in Dharla and Siri varieties (Table 4). Chlorogenic acid content was significantly higher in the seed cake of variety Abirami followed by variety Siri. Lower levels of chlorogenic acid are preferred in the feed as they affect the digestive enzymes. Rutin

Table 3: Nutritive value of tobacco seed, sunflower and groundnut oils

Tobacco variety	Fatty acid (%)			Ratio	Nutritional
	SFA	MUFC	PUFA	PUFA/SFA	class
Dharla	9.80	9.97	79.07	8.1	I
Manasi	10.80	11.68	72.49	6.7	I
GT-7	10.55	11.16	75.79	7.2	I
HDBRG	10.42	10.85	75.65	7.3	I
Abirami	8.22	11.43	75.11	9.1	I
Banket A1	9.38	9.22	73.11	7.8	I
Siri	9.11	13.06	75.30	8.2	I
Sunflower	12	24	64	5.3	I
Groundnut	14	60	20	1.4	II

content varied from 0.21 to 1.90 mg/g in the TSCs. The variety Dharla showed maximum and significantly higher rutin content compared to other TSCs. Rutin is considered to be a good antioxidant. The ash content varied from 0.98 to 1.82% among TSCs and it was at a par among the tobacco types. The crude fiber content varied from 17.02 to 21.99% among the TSCs. De-oiled cake of varieties Manasi (21.21%) and Banket A1 (21.99%) showed significantly higher fiber content compared to other varieties whereas it was at a par among the Abirami, Dharla, Siri and HDBRG. The crude fiber content varied from 14.58 to 16.89% among the varieties of tobacco grown in Bangladesh (Abbas Ali *et al.*, 2008) and 19.9 to 21.2% among the three varieties grown in USA (Frega *et al.*, 1991). The crude fiber content in the tobacco seed cake was higher than the groundnut cake (11%) and sunflower cakes (11-22%) (Frega *et al.*, 1991; Fekria *et al.*, 2012).

The soluble protein was fractionated into albumins, globulins, prolamins and glutilins to study the quality of proteins present in the TSCs. Globulins were the major fraction followed by albumins, glutilins and prolamins (Table 5). Albumin content ranged from 29.47 to 44.38 mg/g in total soluble proteins. The variety Siri contained significantly higher levels of albumins compared to other tobacco varieties. Globulin content varied from 88.06 to 126.94 mg/g of total soluble protein. The variety Banket A1 showed significantly higher globulin content whereas it was significantly lower in the varieties Abirami and HDBRG. Prolamin content ranged from 7.19 to 15.97 mg/g of the soluble protein in the TSCs (Table 5). The varieties Manasi and Banket A1 showed significantly higher content of prolamins compared to other varieties. Glutilin content varied from 25.74 to 30.74 mg/g of the soluble protein among the TSCs. The varieties Siri, HDBRG and Abirami contained significantly higher content of glutilins compared to the other varieties whereas varieties Banket A1, Manasi and Dharla were at a par. The albumins content reported in sunflower cake was higher than tobacco seed cake whereas other fractions were in similar ranges as in sunflower cake (Zilic *et al.*, 2010). The free amino acid content among the TSCs ranged from 0.82 to 1.91 mg/g (Table 5). The variety Abirami contained significantly higher content of free amino acids compared to other varieties.

Total nitrogen content varied from 4.32 to 5.14% among the TSCs (Table 6). The cake of varieties Siri, GT-7 and Abirami showed higher levels of nitrogen compared to other varieties. The phosphorous and potassium contents varied from 0.74 to 0.95% and 1.45 to 2.30%, respectively among the TSC. Calcium, magnesium, sulphur and chloride contents ranged from 0.12 to 2.00%, 0.41 to 0.48%, 0.41 to 0.52% and 0.20 to 0.38%, respectively in TSCs (Table 6). The phosphorous, potassium, calcium and magnesium contents of tobacco seed cakes were higher than sunflower (0.46, 0.74, 1.2 and o.5%) and groundnut (0.65, 1.07, 0.13 and 0.02%) de-oiled seed cakes whereas

Table 4: Biochemical composition of de-oiled tobacco seed cake

Variety	Total proteins (%)	Soluble proteins (%)	Total carbohydrates (%)	Starch (%)	Reducing sugars (%)	Chlorogenic acid (mg/g)	Rutin (mg/g)	Total ash (%)	Crude fiber (%)
GT-7	31.50	18.38	10.24	1.49	0.62	1.99	0.34	1.53	17.02
Abirami	31.75	16.09	9.81	1.69	0.56	2.66	0.22	1.37	18.24
Dharla	29.50	19.31	10.16	2.55	0.92	1.05	1.90	1.44	19.27
Manasi	27.00	18.99	8.40	3.46	0.66	1.98	0.49	0.98	21.21
Banket A1	27.45	20.47	7.92	1.84	0.69	0.94	0.21	1.82	21.99
Siri	32.12	20.37	8.25	2.80	0.91	2.02	0.64	1.20	17.34
HDBRG	30.75	18.23	7.50	2.92	0.70	0.98	0.57	1.52	17.66
SEm ±	**0.778**	**0.368**	**0.30**	**0.088**	**0.033**	**0.087**	**0.046**	**0.194**	**0.49**
CD (P=0.05)	**2.389**	**1.12**	**0.93**	**0.27**	**0.10**	**0.26**	**0.14**	**NS**	**1.50**

Table 5: Soluble protein fractions of de-oiled tobacco seed cake

Tobacco variety	Albumins (mg/g)	Globulins (mg/g)	Prolamins (mg/g)	Glutilins (mg/g)	Free amino acids (mg/g)
GT-7	29.47	119.92	7.19	27.30	1.08
Abirami	32.47	88.06	11.07	29.29	1.91
Dharla	39.78	114.32	12.21	26.89	0.82
Manasi	37.12	109.70	15.97	26.83	1.14
Banket A1	27.81	126.94	14.26	25.74	0.87
Siri	44.38	118.00	10.70	30.74	0.89
HDBRG	34.47	89.20	10.40	30.28	1.24
SEm±	**0.886**	**0.995**	**0.59**	**0.638**	**0.048**
CD (P=0.05)	**2.71**	**3.05**	**1.83**	**1.95**	**0.15**

Table 6: Mineral composition (%) of de-oiled tobacco seed cake

Tobacco variety	N	P	K	Ca	Mg	S	Cl
GT-7	5.04	0.76	1.45	0.12	0.43	0.44	0.26
Abirami	5.08	0.75	1.80	0.14	0.44	0.52	0.32
Dharla	4.72	0.95	2.00	0.13	0.47	0.56	0.33
Manasi	4.32	0.78	2.10	0.12	0.46	0.41	0.20
Banket A1	4.74	0.77	2.30	0.16	0.41	0.45	0.34
Siri	5.14	0.74	2.00	0.18	0.42	0.52	0.32
HDBRG	4.92	0.82	1.98	0.20	0.48	0.50	0.38

nitrogen content of tobacco seed cake was less than seed cakes of sunflower (6.2%) and groundnut (7.7%) (Yawalkar *et al.*, 1981; Rao *et al.*, 2011).

The physical characters of tobacco seed oil were compared with the sunflower and groundnut oils. The Refractive index of tobacco seed oil at 27°C (1.474) was similar to the sunflower oil (1.469) and groundnut oil (1.471). Relative viscosity of tobacco seed oil at 27°C (1.27) was higher than that of sunflower oil (1.00) and closer to the groundnut oil (1.20). Specific gravity of tobacco seed oil (1.178) was higher than the sunflower oil (1.03) and groundnut oils (1.02). Specific gravity and refractive index are very stable parameters and can be used for identification of the oils. Higher value of the tobacco seed oil was due to higher degree of unsaturation as well as higher molecular weights.

Thus, the physical and chemical characteristics of tobacco seed oil are comparable with other edible oils. Tobacco seeds of different varieties reported herein contain higher per cent of unsaturated fatty acids as compared to saturated fatty acids which is a characteristics of vegetable oils. From the quality point of view, tobacco seed oil is comparable to other oils and can be utilized in food and paint industries as a potential raw material. The tobacco seed cake after extraction of oil is rich in nitrogen (around 5%) and could serve as animal feed supplement. Protein and high fiber content also commands tobacco seed cakes as a nutritive component. The results showed considerable variability among the varieties which may be attributed to genetic variability and helpful for selection of varieties. Further study is needed to understand the maturity, growing region, harvesting and storage period influence on characteristics of oil and nutritive values of the tobacco seeds.

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