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Physico-chemical and sensory evaluation of groundnut and cottonseed oil blends

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Abstract
Groundnut oil was blended with cottonseed oil for the enhancement of its physico-chemical properties and sensory characteristics. The physico-chemical properties like colour, specific gravity, smoke point, moisture content, peroxide value, acid value, free fatty acids and oil retention capacity of groundnut and cottonseed oil blends in 80:20 to 20:80 proportions were evaluated along with the sensory attributes. The results showed decline in acid value, free fatty acids, peroxide value and improvement in sensory characteristics of groundnut and cotton seed oil blends when compared to the unblended groundnut oil making the blend more preferable for consumption.

Keywords: Groundnut oil, cotton seed oil, specific gravity, smoke point, acid value, free fatty acids, peroxide value, colour, oil retention capacity, sensory evaluation

Introduction
The vegetable oils have limited technological application in their original form due to their specific physicochemical properties which do not meet consumer satisfaction in terms of the texture and stability of food products. Their commercial application can be enhanced by blending vegetable oils to obtain desired textural and oxidative properties (Hashempour-Baltork, 2016) [4].

The blending of different oils offers consumers a better quality product with respect to flavour and nutritive value. The unconventional oils like cottonseed and soybean are being accepted since the last 10 years and this indirectly helped in stabilizing the price of edible oils (Chopra *et al*., 2004) [3]. Blending of oils can provide protective advantage against oxidation by improving the frying recyclability (Toliwal *et al*., 2005) [12].

Cottonseed oil was termed as "Heart oil" among unsaturated edible oils due to its good keeping quality because of tocopherols (Alderks, 1948) [1]. Linoleic acid is the major polyunsaturated fatty acid in cottonseed oil and considered as a healthy vegetable oil. Cottonseed oil is "naturally hydrogenated" due to presence of oleic, palmitic, and stearic acids, renders as stable frying oil without any additional processing that result in formation of trans fatty acids. Refining of cottonseed oil removes gossypol, the naturally occurring toxin as it is the main hindrance in its acceptance by consumers (Kanoi, 2005) [6].

Material and Methods
Procurement of raw materials: Vegetable oils, besan flour, wheat flour and onions were purchased from local markets of Hyderabad.

Preparation of oil blends: The edible groundnut and cottonseed oils were blended in the ratios of 80:20, 70:30, 60:40, 50:50, 40:60, 30:70 and 20:80. These oils were heated by preparing pakoras for about 20 min, cooled, filtered and stored till further use.

Analysis of physicochemical properties: Both the fresh and heated oil blends were studied for physicochemical properties like specific gravity, smoke point, moisture content, peroxide value and acid value using standard procedures of FSSAI manual (2016), colour using Hunter lab colorimeter (Hunter Lab, 2013) [5], free fatty acids (AOAC, 1940) and oil retention capacity (Beugre *et al.*, 2014) [2].

Sensory evaluation: A semi-trained panel of 15 members from PGRC, PJTSAU evaluated using 9 point hedonic scale deep fried pakoras prepared using different ratios of oil blends for colour, texture, flavour, taste and overall acceptability.

The scores on hedonic scale of 1 to 9where: 1 = I dislike extremely (very bad) and 9 = I like extremely (excellent). The panellists in individual booths of sensory evaluation lab were provided with samples in plates coded with three digit numbers and were asked to rinse their mouth with water after testing each sample (Meilgaard *et al.*, 1999) [7].

Statistical analysis: All the results were statistically analysed to test the significance using percentages, means and standard deviations (Snedecor and Cochran, 1983) [11].

Results and Discussion: The results of the present study can help to develop economically viable oil blends for cooking purpose with maximum nutrition, desirable physico-chemical properties, sensory characteristics and storage stability.

Colour: The results of colour scores of the fresh and heated oil blends were presented as L*, a*, b* and E* values in Table 1, which were analysed using Munsell colour charts. The L* value ranged from 0 to 100 indicating luminance or lightness component along with two chromatic components a* component (from green to red) and the b* component (from blue to yellow). The L*a*b* units are often used in food research studies because of uniform distribution of colours and L*a*b* units are very close to human perception of colour.

Table 1: Colour values for blend with groundnut and cottonseed oils

S. No.	Mixture ratio	ΔL		Δa		Δb		ΔE	
		F	H	F	H	F	H	F	H
1	80:20	-33.89^{a} ±0.08	-33.48^{c} ±0.04	52.99^{a} ±0.26	55.53^{abc} ±0.21	6.17^{a} ±0.29	6.54^{a} ±0.29	65.17^{a} ±0.14	65.03^{ab} ±0.23
2	70:30	-33.86^{ab} ±0.06	-33.52^{bc} ±0.11	55.63^{b} ±0.09	55.60^{bc} ±0.03	6.99^{b} ±0.18	6.67^{ab} ±0.17	65.51^{a} ±0.11	65.26^{b} ±0.10
3	60:40	-33.67^{b} ±0.01	-33.99^{a} ±0.08	55.33^{ab}±0.02	55.40^{ab} ±0.17	6.35^{ab} ±0.28	6.58^{a} ±0.20	65.08^{a} ±0.02	65.32^{b} ±0.19
4	50:50	-33.91^{a} ±0.11	-33.86^{ab} ±0.06	55.56^{b} ±0.24	55.60^{bc} ±0.16	6.35^{ab} ±0.29	6.77^{ab} ±0.04	65.40^{a} ±0.21	65.45^{b} ±0.14
5	40:60	-33.79^{ab} ±0.02	-33.35^{c} ±0.21	55.43^{ab}±0.25	55.53^{bc} ±0.13	6.14^{a} ±0.28	6.98^{ab} ±0.29	65.21^{a} ±0.28	65.15^{ab} ±0.09
6	30:70	-33.89^{a} ±0.06	-33.27^{c} ±0.21	55.47^{ab}±0.12	55.97^{c} ±0.01	6.52^{ab} ±0.29	7.40^{b} ±0.29	65.32^{a} ±0.09	65.53^{b} ±0.08
7	20:80	-33.99^{a} ±0.05	-33.22^{c} ±0.21	55.45^{ab}±0.06	55.09^{ab} ±0.18	6.60^{ab} ±0.26	7.14^{ab} ±0.28	65.37^{a} ±0.04	64.72^{a} ±0.23
8	Mean	-33.86	-33.48	55.40	55.53	6.44	6.86	65.29	65.20
9	S.E. of mean	0.03	0.08	0.07	0.07	0.10	0.10	0.05	0.07
10	C.D.	0.21	0.46	0.52	0.49	0.68	0.77	0.48	0.53
11	C.V. (%)	-0.35	-0.78	0.53	0.49	5.95	6.30	0.41	0.46

Note: Values are expressed as mean ± standard deviation of three determinations.

80:20 = 80% groundnut + 20% cottonseed oil 40:60 = 40% groundnut oil + 60% cottonseed oil
70:30 = 70% groundnut + 30% cottonseed oil 30:70 = 30% groundnut oil + 70% cottonseed oil
60:40 = 60% groundnut + 40% cottonseed oil 20:80 = 20% groundnut oil + 80% cottonseed oil
50:50 = 50% groundnut + 50% cottonseed oil F = Fresh oil blend
H = Heated oil blend

Means within the same column followed by a common letter do not differ significantly at $p \leq 0.05$

No significant difference ($p<0.05$) was found in colour values of oil blends. The blends in comparison with unblended groundnut oil showed change in colour value Δb with no significant change in colour values of ΔL, Δa and ΔE. All the fresh blends showed decrease in Δb values of 10% to 20% whereas heated blends showed increase in Δb values by 40% to 60% (Figure 1).

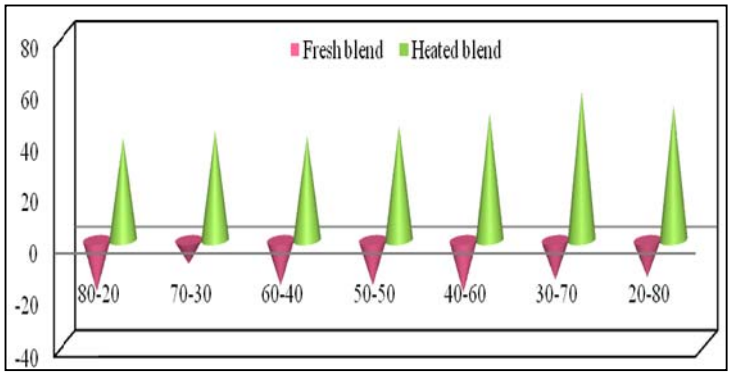

Fig 1: Percentage change in colour value Δb for oil blends

Specific gravity: Specific gravity is the heaviness of a substance in comparison with water, without any units. The specific gravity obtained for all the fresh and heated oil blends were above 1.0 when measured at 30°C with no significant difference at $p \leq 0.05$ for all the samples as shown in Table 2.

Smoke point: The smoke point of oil is the temperature at which continuous bluish smoke is clearly visible and can be correlated to the level of refinement. The mean scores of smoke points of all the fresh and heated oil blends were tabulated in the Table 2. The results showed higher smoke points for fresh and heated oil blends when compared with standard cooking temperatures for deep frying (160^0C - 180^0C). The smoke point of both fresh and heated oil blends with 80% cottonseed oil was high than other blends. Significant difference ($p \leq 0.05$) was found in oil blends with 50% and 60% cottonseed oil than other blends.

Moisture content: The moisture content of the oil is correlated to long storage life making them economically viable. The maximum limit of moisture in edible oils is 0.1%-0.5% (Pomeranz, *et al*., 1987) [9]. The study showed that both the fresh and heated oil blends of different mixing proportions had zero moisture content in them (Table 2).

Peroxide value: The peroxide value determines the degree of oxidation of oil for identifying the level of deterioration of oils and fats (Okechalu *et al*., 2011) [8]. The mean scores showed a low peroxide values for fresh oil blends whereas peroxide values increased for heated oil blends but they were all within the permissible limits.

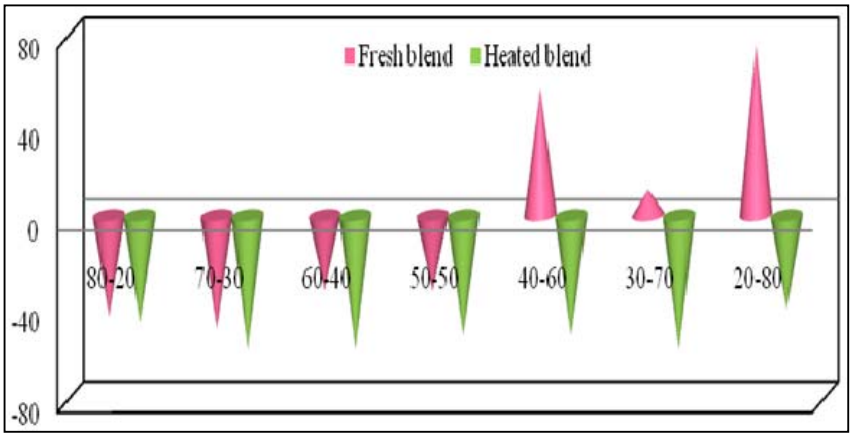

Fig 2: Percentage change in peroxide values for oil blends

Significant difference ($p \leq 0.05$) was found between various oil blends. As depicted in Figure 2 the fresh oil blends with 30%, 20%, 40% and 50% cottonseed oil showed decreased peroxide values of 50.0%, 44.6%, 33.3% and 33.3% respectively. All the heated oil blends showed decrease in peroxide values.

Table 2: Physicochemical parameters of blend with groundnut and cottonseed oils

S. No.	Mixture ratio	Specific gravity at 30^0C		Smoke point (^{0}C)		Moisture content (%)		Peroxide value (meq/kg)		Acid value		Free fatty acids (% oleic acid)	
		F	H	F	H	F	H	F	H	F	H	F	H
1	80:20	$1.08^{a}\pm$ 0.02	$1.07^{a}\pm$ 0.02	$228.70^{ef}\pm$ 0.60	$211.70\pm$ 0.60	0	0	$1.33^{a}\pm$ 0.12	$18.00^{c}\pm$ 0.00	$4.20^{a}\pm$ 0.12	$5.60^{a}\pm$ 0.00	$0.03^{a}\pm$ 0.00	$0.03^{a}\pm$ 0.00
2	70:30	$1.07^{a}\pm$ 0.02	$1.07^{a}\pm$ 0.02	$227.30^{cd}\pm$ 0.60	$217.70\pm$ 0.60	0	0	$1.20^{a}\pm$ 0.00	$14.00^{a}\pm$ 0.00	$5.20^{c}\pm$ 0.15	$6.47^{b}\pm$0.15	$0.03^{a}\pm$ 0.00	$0.03^{a}\pm$ 0.00
3	60:40	$1.08^{a}\pm$ 0.02	$1.07^{a}\pm$ 0.02	$226.70^{c}\pm$ 0.60	$199.30\pm$ 0.60	0	0	$1.60^{a}\pm$ 0.00	$14.00^{a}\pm$ 0.00	$5.10^{c}\pm$ 0.00	$5.80^{a}\pm$ 0.15	$0.04^{b}\pm$ 0.00	$0.04^{b}\pm$ 0.00
4	50:50	$1.09^{a}\pm$ 0.00	$1.08^{a}\pm$ 0.02	$219.70^{b}\pm$ 0.60	$215.30\pm$ 0.60	0	0	$1.60^{a}\pm$ 0.46	$16.00^{b}\pm$ 0.00	$4.77^{b}\pm$ 0.01	$6.37^{b}\pm$ 0.17	$0.04^{b}\pm$ 0.00	$0.04^{b}\pm$ 0.00
5	40:60	$1.07^{a}\pm$ 0.02	$1.07^{a}\pm$ 0.02	$218.30^{a}\pm$ 0.60	$209.70\pm$ 0.60	0	0	$3.73^{c}\pm$ 0.46	$16.00^{b}\pm$ 0.00	$4.50^{b}\pm$ 0.10	$6.23^{b}\pm$ 0.15	$0.04^{c}\pm$ 0.00	$0.04^{b}\pm$ 0.00
6	30:70	$1.08^{a}\pm$ 0.02	$1.08^{a}\pm$ 0.02	$229.70^{f}\pm$ 0.60	$200.70\pm$ 0.60	0	0	$2.66^{b}\pm$ 0.12	$14.00^{a}\pm$ 0.00	$5.10^{c}\pm$ 0.00	$6.77^{c}\pm$0.07	$0.04^{c}\pm$ 0.00	$0.05^{c}\pm$ 0.00
7	20:80	$1.09^{a}\pm$ 0.00	$1.08^{a}\pm$ 0.02	$228.30^{de}\pm$ 0.60	$225.30\pm$ 0.60	0	0	$4.20^{c}\pm$ 0.44	$20.00^{d}\pm$ 0.00	$5.73^{d}\pm$ 0.13	$6.97^{d}\pm$ 0.07	$0.05^{c}\pm$ 0.00	$0.05^{c}\pm$ 0.00
8	Mean	1.08	1.07	225.52	211.38	-	-	2.33	16	4.94	6.31	0.04	0.04
9	S.E. of mean	0	0.01	4.36	8.78	-	-	1.18	2.19	0.11	0.11	0	0.01
10	C.D.	0.03	0.01	1.02	0.95	-	-	0.47	0	0.28	0.33	0.01	0
11	C.V. (%)	1.37	0.29	0.26	0.25	-	-	11.26	0	3.21	2.97	6.96	5.52

Note: Values are expressed as mean ± standard deviation of three determinations.
Means within the same column followed by a common letter do not differ significantly at $p \leq 0.05$

80:20 = 80% groundnut oil + 20% cottonseed oil
70:30 = 70% groundnut oil + 30% cottonseed oil
60:40 = 60% groundnut oil + 40% cottonseed oil
50:50 = 50% groundnut oil + 50% cottonseed oil
40:60 = 40% groundnut oil + 60% cottonseed oil
30:70 = 30% groundnut oil + 70% cottonseed oil
20:80 = 20% groundnut oil + 80% cottonseed oil
F = Fresh blend of groundnut and cotton seed oils
H = Heated blend of groundnut and cotton seed oils

Acid value: Acid value measures the extent to which glycerides in oil were decomposed by lipase enzyme due to physical factors like light, heat and moisture. The results showed low acid values for both fresh and heated oil blends indicating lower levels of triglyceride decomposition.

Significant difference ($p \leq 0.05$) was found in fresh oil blends and in heated oil blends with 40% and 60% cottonseed oil. When compared to the groundnut oil, the oil blends showed decrease of 5% to 30% for fresh oil blends and 10% to 25% for heated oil blends (Figure 3).

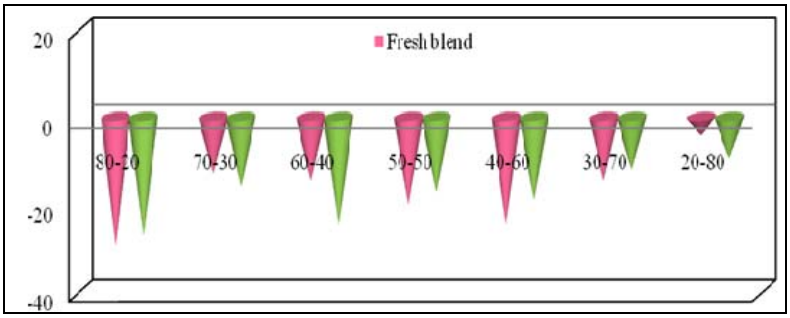

Fig 3: Percentage change in acid value for oil blends

Free fatty acids: The results obtained in the present study indicated that the acid value of both fresh and heated oil blends corresponded to low levels of free fatty acids suggesting that less hydrolytic and lipolytic activities in the oil blends was observed. There was not much difference between fresh and heated oil blends.

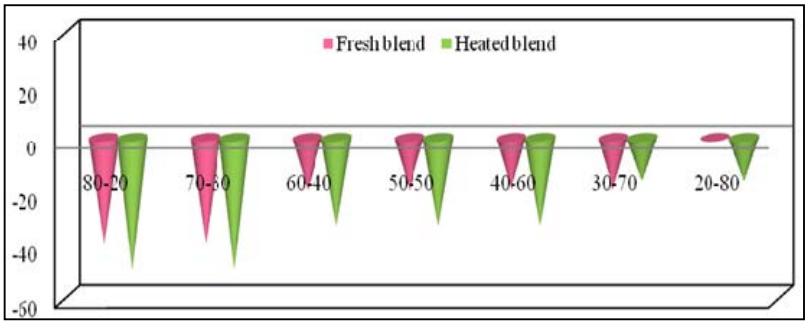

Fig 4: Percentage change in free fatty acids for oil blends

Significant difference ($p \leq 0.05$) was found between various oil blends. When compared to the groundnut oil, the fresh and heated oil blends showed decrease by 20 to 40% and 16.67 to 50% (Figure 4).

Oil retention capacity: The mean scores for oil retention capacity (ORC) of wheat and besan flours for both fresh and heated oil blends were very high (Table 3). The retention of higher quantities of oil blends by flours can help to improve the structure of final products and improve sensory properties like flavour, taste and mouthfeel. Also the oil absorption is commonly attributed to the physical entrapment of fat by proteins. No significant difference was found in ORC of wheat and besan flours for both fresh and heated oil blends at different mixing proportions.

Table 3: Oil retention capacity of wheat and besan flours with oil blends

S. No.	Mixture ratio	ORC (Wheat flour)		ORC (Besan flour)	
		F	H	F	H
1.	80:20	$2.49^{bc}\pm0.06$	$2.29^{ab}\pm0.03$	$2.29^{b}\pm0.05$	$2.34^{ab}\pm0.06$
2.	70:30	$2.39^{a}\pm0.04$	$2.28^{ab}\pm0.01$	$2.42^{c}\pm0.04$	$2.35^{ab}\pm0.04$
3.	60:40	$2.40^{ab}\pm0.02$	$2.32^{bc}\pm0.01$	$2.38^{bc}\pm0.05$	$2.27^{a}\pm0.08$
4.	50:50	$2.38^{a}\pm0.01$	$2.27^{a}\pm0.04$	$2.30^{b}\pm0.02$	$2.46^{c}\pm0.02$
5.	40:60	$2.52^{c}\pm0.05$	$2.34^{c}\pm0.03$	$2.47^{c}\pm0.04$	$2.33^{ab}\pm0.05$
6.	30:70	$2.32^{a}\pm0.08$	$2.30^{abc}\pm0.01$	$2.20^{a}\pm0.02$	$2.37^{bc}\pm0.06$
7.	20:80	$2.41^{ab}\pm0.07$	$2.30^{abc}\pm0.03$	$2.27^{ab}\pm0.02$	$2.32^{ab}\pm0.02$
8.	Mean	2.41	2.30	2.33	2.35
9.	S.E.	0.02	0.03	0.03	0.07
10.	C.D.	0.09	0.05	0.11	0.09
11.	C.V. (%)	2.18	1.13	2.68	2.24

Note: Values are expressed as mean ± standard deviation of three determinations.
Means within the same column followed by a common letter do not differ significantly at $p \leq 0.05$

80:20 = 80% groundnut + 20% cottonseed oil
70:30 = 70% groundnut + 30% cottonseed oil
60:40 = 60% groundnut + 40% cottonseed oil
50:50 = 50% groundnut + 50% cottonseed oil
40:60 = 40% groundnut oil + 60% cottonseed oil
30:70 = 30% groundnut oil + 70% cottonseed oil
20:80 = 20% groundnut oil + 80% cottonseed oil
F = Fresh oil blend
H = Heated oil blend

Sensory evaluation: The mean scores of sensory evaluation for the oil blends were depicted in Fig 6. The sensory scores for colour ranged from 8.25 to 8.75, texture from 7.63 to 8.63, taste from 7.63 to 8.88, flavour from 7.75 to 8.63 and overall acceptability from 7.75 to 8.88. The blend with 70% cottonseed oil showed highest sensory scores for colour, flavour and overall acceptability while the blend with 60% cottonseed oil showed highest sensory scores for texture and flavour. However the highest sensory score for taste was observed for blend with 40% cottonseed oil.

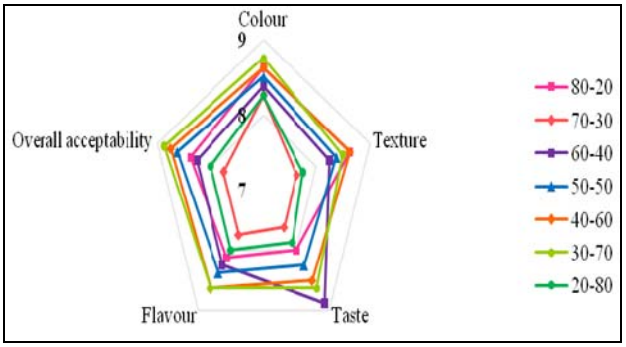

Fig 5: Sensory characteristics of oil blends

No significant difference ($p \leq 0.05$) was found for colour, taste, flavour and overall acceptability whereas for texture the significant difference was found between 80% and 40% cottonseed oil blends. When compared to the groundnut oil, the blend with cottonseed oil showed markedly high increase in colour for blends of 80:20 and 40:60 by 11.35%, texture for blends of 40:60 and 80:20 by 25%, taste for blends of 60:40 and 30:70 by 29.07% and 25.44% respectively, flavour for blends of 40:60 and 30:70 by 30.16% and overall acceptability for blends of 30:70 and 40:60 by 25.54% and 22.72% respectively (Figure 6).

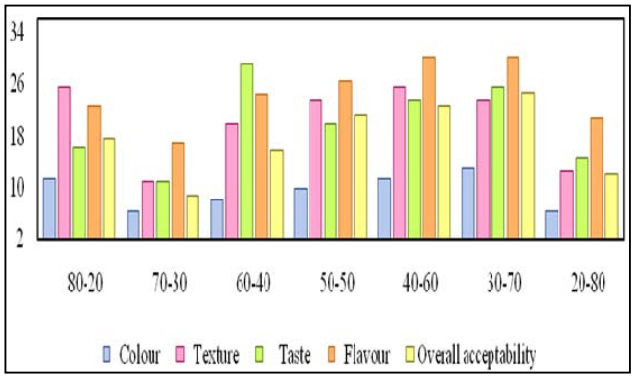

Fig 6: Percentage change in sensory characteristics for oil blends

Conclusion

The blending of groundnut oil with cottonseed oil resulted in reducing the peroxide value, acid value, free fatty acids of both fresh and heated oil blends and improved the sensory characteristics of pakoras. The utilization of cottonseed oil for human consumption should receive immediate attention in India for meeting the shortage of edible oil (Mehta, 2006). It contains more than 50% of poly-unsaturated fatty acids and is very ideal to be included in human diets. Cottonseed oil is very popular in USA (Young and Westcott, 2000). However, in India, it is used to a very small extent by large. Therefore, efforts are to be made on a war footing to popularize its use in our country, which can eventually result in stoppage of import of edible oils to a certain extent (Sekhar and Bhaskara Rao, 2011) [10].

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