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COTTONSEED OIL QUALITY, UTILIZATION AND PROCESSING

Dinesh K. Agarwal
Phundan Singh
Mukta Chakrabarty
A J Shaikh
S G Gayal

Central Institute for Cotton Research
Nagpur

PREFACE

Cotton is an important fibre crop of global significance and is grown in tropical and sub-tropical regions of more than eighty countries. Cotton is primarily cultivated for its lint or fibre, in other words, lint is the main product of cotton crop. Now, cotton seed oil is also widely used for human consumption. Thus, cotton has become a fibre cum oil yielding crop. Its seeds also contains 20-25% protein. Hence, in future, cotton will become a source of fibre, oil and protein. There are four products of cotton plant viz.lint, seed, stalk and leaves. Out of these, lint is the main product and rest are by-products. The information on the utilization of cotton byproducts is very scanty and that too is not available in any single source.

This bulletin is first of its kind that provides comprehensive information about various aspects of cottonseed oil processing, utilization and quality. The information contained in this bulletin has been gathered from various published sources.

Hope this bulletin would be useful to researchers, seed crushers, teachers and students engaged with cotton crop.

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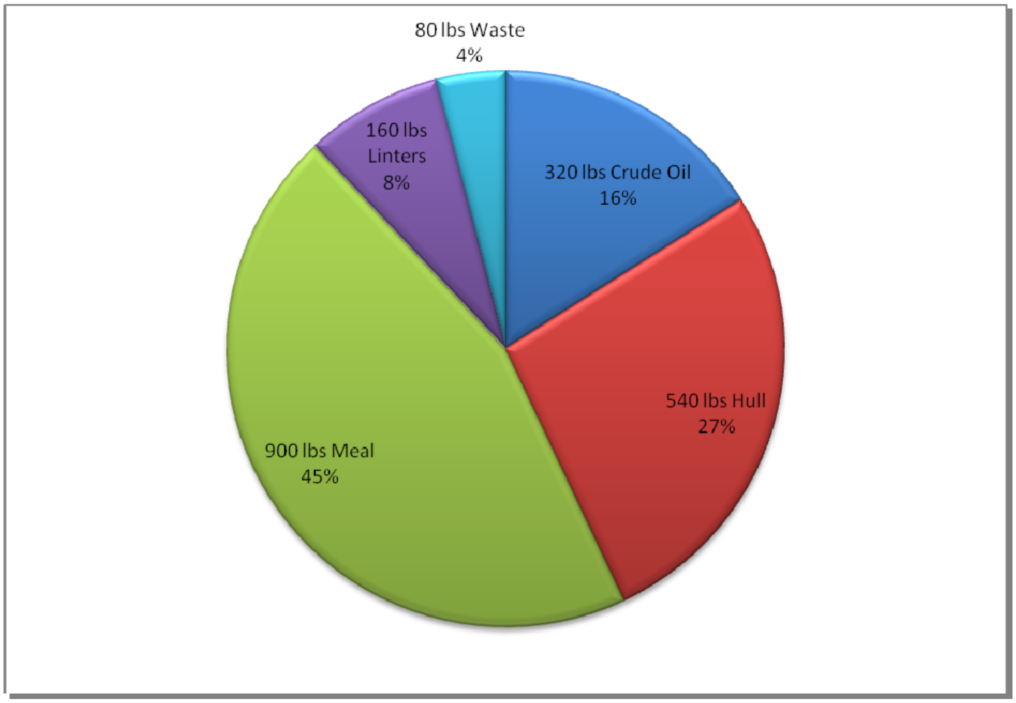
COTTONSEED OIL QUALITY, UTILIZATION AND PROCESSING

1.0 Introduction

Cotton is one of the most important commercial crops of India and is the single largest natural source of fibre. It plays a dominant role in its agrarian and industrial economy as the backbone of textile industry, which consumes 70% of the country's total fibre produced. It alone accounts for 38% of the country's export and fetches over Rs. 42,000 crores annually to the exchequer. Thus, cotton production plays a vital role in Indian economy, providing employment for more than one million farmers and employees in the domestic textile industry. But, textiles are only the part of this great cotton story. The often-ignored fact is that the cotton plant produces more food for man and feed for animals than fibre. All elements of cotton seed as it is often considered as "Golden Goose": linters, kernels and hulls are used in various consumer products, delicious food and nutritious feed for animals (Figure 1).

Figure 1. Cottonseed products yield per ton of seed crushed.



National Cottonseed Products Association, 2000

2.0 Cottonseed Oil

Cottonseed contains hull and kernel. The hull produces fibre and linters. The kernel contains oil, protein, carbohydrate and other constituents such as vitamins, minerals, lecithin, sterols etc. Cottonseed oil is extracted from cottonseed kernel. Cottonseed oil, also termed as "Heart Oil" is among the most unsaturated edible oils. It need not be as fully hydrogenated for many a cooking purposes as is required in case of some of the more polyunsaturated oils.

Refined and deodorised cottonseed oil is considered as one of the purest cooking medium available. An additional benefit that accrues from Cottonseed Oil is its high level of antioxidants - tocopherols.

3.0 Cottonseed Oil Quality

Fats and oils are made up of triglycerides, three molecules of fatty acids joined to a glycerol molecule. The chain length of the fatty acids and their organization on the glycerol backbone vary greatly, although in most of the edible oils it is with 16 and 18 carbons. Fats and oils are a combination of fatty acids, both saturated (C14:0, 16:0, etc.) and unsaturated (C 18:1, 18:2, 18:3). Some fats, such as lard, palm and coconut oils, have higher concentrations of saturated fatty acids than other oils and are referred to as saturated fats, even though they contain some percentages of unsaturated fatty acids. Cottonseed oil is among the most unsaturated oils, others being safflower, corn, soybean, rapeseed and sunflower seed oils. Cottonseed oil has a ratio of 2: 1 of polyunsaturated to saturated fatty acids and generally consists of 65-70% unsaturated fatty acids including 18-24% monounsaturated (oleic) and 42-52% polyunsaturated (linoleic) and 26-35% saturated (palmitic and stearic).

3.1 Cottonseed Oil - Nutritional Aspects

Cottonseed oil is cholesterol free, as are all oils extracted from plants. Linoleic acid is the major polyunsaturated fatty acid found in cottonseed oil (Table 1). With three times as much unsaturated as saturated fatty acid, cottonseed oil is considered as a healthy vegetable oil and is one of the few oils advised for reducing saturated fat intake. Cottonseed oil is described by scientists as being "naturally hydrogenated" because of the levels of oleic, palmitic, and stearic acids in it. This renders it a stable frying oil without the need for additional processing that could lead to the formation of trans fatty acids. When it is partially hydrogenated, its monounsaturated fatty acids actually increase. When hydrogenated to a typical Iodine Value of about 80, its fatty acid profile changes to 50% monounsaturated, 21 % polyunsaturated, and 29% saturates all well within health guidelines.

Table 1: Typical Fatty Acid Composition in different forms of Cottonseed oil

FATTY ACID	COTTONSEED COOKING OIL	*PARTIALLY HYDROGENATED
Myristic (14:0)	0.8	0.9
Palmitic (16:0)	24.4	22.5
Palmitoleic (16:1)	0.4	0
Stearic (18:0)	2.2	5.5
Oleic (18: 1)	17.2	50.0
**Linoleic (18:2)	55.0	20.3
**Linolenic (18:3)	0.3	0.3
SUMMARY		
% Saturates	27	29
% Monounsaturates	18	50
% Polyunsaturates	55	21

*Partially hydrogenated cottonseed oil (Iodine Value, approximately 80)
**Essential Fatty Acids; Linolenic is an Omega-3 Fatty Acid.

As mentioned earlier, another of cottonseed oil's benefits is its high level of antioxidants - tocopherols that contribute to its long life on the shelf. Studies show that these natural antioxidants are retained at high levels in fried products, preserving their freshness and creating longer shelf life. Cottonseed oil is rich in tocopherols (Table 2).

Table 2: Tocopherol contents in various edible Oils

Oil Crop	Total (mg/100 g)	Contents (mg/100 g)			a-Tocopherol equivalent
		a	b	g	
Canola	66	19	43	4	23
Corn	104	26	75	3	33
Cottonseed	65	35	30	-	38
Olive	13	12	1	-	12
Palm	26	6	11	9	8
Peanut	13	9	4	1	9
Rapeseed	67	22	19	26	24
Soybean	104	10	70	24	17
Sunflower	65	62	3	-	62

(*Source: The National Cottonseed Products Association -Guide to Edible Oils.*)

These natural antioxidants, with varying degrees of vitamin E activity, give products that contain it a long shelf life. Several different tocopherols having vitamin E activity has been found in plants; the most active and abundant are a - tocopherol. Table 2 gives a clear idea about cottonseed oil's superior quality in terms of total a - tocopherol equivalent over the most of edible oils.

3.2 Cottonseed oil - an analytical evaluation

Cottonseed oil is often used as the standard for measuring flavour and odour qualities of other oils. Cottonseed oil has a mild taste. It is generally clear with a light golden colour, but like most oils, the degree of colour depends on the amount of refining. Clear, colourless oils are not necessarily better oils, but may have been refined more severely. Cottonseed oil's light, non oily consistency and high smoke point make it most desirable for stir-fry cooking, as well as for frying. Analytical values on different parameters for various cottonseed oil forms are given in Table 3.

	Cottonseed Cooking Oil (RBD)*	Hydrogenated Cottonseed Shortening
Lovibond Colour (Red Max.)	2.0-6.0	2.0-2.5
Free Fatty Acid (as Oleic % Max.)	0.05	0.05
Peroxide Value (Meq/kg. Max.)	1.0	0.5

Iodine Value	103-116	50-70
AOM Stability (hrs.)	15	100-200+
Cloud Point (°F)	30-38	-
Melting Point (°F)	50-60	100-118
Pour Point (°F)	-	102-140
Smoke Point (°F)	430	-
Cold Test (hrs.)	-	-
Flavour	Bland	Bland
Density (lb/gal @ 108°C)	-	7.46

* RBD - Refined, Bleached & Deodorized ; *CSO Bulletin, 2000 Digital Edition Published on www.cottonseed.com*

3.3 Cottonseed oil - deterioration

If subjected to stress in the cooking process, oils are changed. These stresses can produce undesirable reactions and reaction products (Table 4) leading to deterioration in the performance of the oil. Many factors which can initiate degradation reactions, include heat, light (especially UV), metals, salts, water, and other foods. One of the roles of proper packaging is to protect oils from these reactions.

Table 4: Various processes involved in oil deterioration

Process	Causing Agents	Chemical Reaction	Effect on Oil Quality	Remarks
Oxidation	Metals, light, heat and especially peroxides.	Formation of hydrocarbons, ketones, aldehydes, epoxides and alcohols.	Off-flavours which lead to rejection by the consumer.	Prevented by antioxi-dants and/or by packaging.
Hydrolysis	Water released from the cooking food and traces of caustic cleaners	The ester bonds between the glycerol backbone of the triglyceride and the fatty acids are hydrolysed.	Diglycerides, monoglycerides and free fatty acids are produced.	The mono and diglycerides are emulsifiers, which further promote hydrolysis reactions.
Polymerisation	Heating oils	The breakdown products in the oil react with one another to form a wide range of compounds including both oxidative and thermal polymers.	Polymers begin to deposit-out on fryer walls, forming the brown coating visible on dirty fryers.	Polymers contribute to foaming, increased viscosity and darkening of the oil.
Pyrolysis	Overheating	Acrolein is formed from the glycerine left from the hydrolysis of triglycerides	Acrolein, a pungent irritant makes the working environment quite uncomfortable.	

There are certain rapid tests to ascertain the oil degradation (Table 5).

Table 5: Rapid tests for fat & oil degradation

Type of test	Indication
Physical tests / no instruments	
Foam height	Excess surfactants
Colour wands	Bitter tasting materials
Clarity	Minimum emulsified water
Physical tests / instruments	
Viscosity tubes	Polymer in oil
Chemical tests / no instruments	
Coat	Potential of oil pickup on food
Ruler	Potential of oil pickup on food
Food oil sensor	Salt, water and electrolytes
Chemical quick tests	
Oxifrit	Oxidised fatty acids
Fritest	Polar materials
TPM, FFA, WET	Total polar materials, free fatty acids, water emulsion titratables
Shortening monitor	Acidity {as %FFA)

3.4 Toxic elements- cottonseed pigments

Cottonseed contains gassypurpurin, gossycaerulin, gossyfulivin, gossyverdurin and gossypol. Gossypol is yellow, gossypurpurin - purple, gossyfulvin - orange, gossycaerulin-blue and gossyverduin- green. The gossypol content is greater in raw material than in cooked cottonseed, whereas gossypupurin and gossyfulvin are found in higher proportion in cooked seed. Gossypol.is the most important pigment present in the cottonseed and create enormous problem of seed processing and utilisation of cottonseed as by-product. Gossypol is located all over in plant. It gives undesirable colour to the oil and reacts with protein to reduce the nutritive value of cottonseed product. It is toxic to non-ruminant animal. Several new processes and solvents have been tried to remove the pigment from cottonseed so that it can be used for edible purposes without any adverse effect. Efforts are also being made to develop new varieties free from gossypol. There are considerable variations in gossypol content from variety to variety within the same species. (Pande 1998). Gossypol is in the free state in the whole seed and on cooking of cottonseed forms "bound gossypol" as a result of gossypol combining with either free amino or free carboxy groups of cottonseed protein. Bound gossypol decreases the nutritive value of protein and availability of lysine, an essential amino acid. Table 6 shows mean gossypol content and the range of gossypol in different gossypium species.

Table 6: Mean gossypol content and the range of gossypol in different gossypium species (% free gossypol)

Species	Seed	Kernel
G. arboreum	0.69 (0.30-1.25)	1.31 (0.65- 2.38)
G. herbaceum	0.77 (0.43-1.09)	1.44 (0.82-1.96)
G. hirsutum	0.77 (0.42-1.25)	1.39 (0.73-2.35)
G. barbadense	1.11 (0.73-1.49)	1.78 (1.22- 2.35)

3.5 Genetic Improvement of Cottonseed Oil Quality

The range of fatty acid content of four cotton species

Name of the species	Extent of Variability				Reference
	Palmitic acid %	Stearic acid%	Oleic acid %	Linoleic acid %	
G. arboreum	23.1-25.9	2.3-3.4	20.8-6.3	41.1-50.6	Pande (1998)
G. herbaceum	20.5-23.4	3.2-4.4	17.5-20.8	51.3-55.1	Pande (1998)
G. hirsutum	23.1-28.0	2.4-3.4	14.7-20.9	47.6-55.4	Pande (1998)
G.barbadense	24.4-25.5	2.6-3.0	18.7-19.7	50.0-51.7	Pande (1998)
G. arboreum	8.90-21.2	1.1-2.9	16.5-30.7	30.3-59.3	Dani et al., (1997)
G. hirsutum	8.83-24.4	1.2-4.5	10.3-30.2	20.6-58.0	Dani et al., (1997)

Extent of variability witnessed in fatty acid profiles in above mentioned studies for all the cultivated cotton species could well be utilised in developing lines with high polyunsaturated and monounsaturated fatty acid contents through appropriate breeding techniques.

The global collection evaluated at Central Institute for Cotton Research, Nagpur, also indicated the presence of a number of lines of *G. hirsutum* and *G. arboreum* having good linoleic and oleic acid content in fatty acid profile (Table 7).

Table 7: High Linoleic acid lines and High Oleic acid lines in *G.hirsutum*

Sr. No.	Name of the germplasm lines	Linoleic acid (%)	Oleic acid (%)
High Linoleic acid lines			
G. hirsutum			
1	IC 18	60.43	27.36
2	JK 345	59.95	27.36
3	68x22	57.08	25.64
4	LH 372	56.26	29.84

5	CL-20-cc	56.04	27.69
6	UK-51	56.0	19.87
7	B-56-181	55.82	20.41
8	DCI 116	55.64	22.11
9	MA 7	55.56	21.65
10	D-40	55.38	22.30
11	DCI 122	55.25	20.73
12	DHY 286	55.13	21.90
High Linoleic acid lines			
G. arboreum			
1.	Gaorani	54.74	31.45
2.	Malvi 20	54.37	23.98
3.	AKH 235	54.13	23.98
4.	Malsona	53.86	28.79
5.	Cocandas - WH	53.66	24.46
6.	N - 21	53.09	29.28
7.	Jarilla	52.70	25.66
8.	Gaorani CB -5	52.10	29.66
High Oleic acid lines			
G. hirsutum			
1	H 655	31.27	46.97
2	GISC-77-4C	30.35	53.04
3	H-655-3	30.27	45.82
4	LH-372	29.84	38.96
5	86-1-A-1	29.42	47.23
6	Empire-W-R	28.35	47.23
7	M-26cc	28.27	49.24
8	PKV 804	28.21	49.91
9	125-CO2-B	28.06	50.82
10	CL-20cc	27.69	51.75
11	JK345	27.36	59.95
12	10 MB	26.87	52.86
13	MCU 5	26.82	43.35
14	UK-55-1	26.75	52.92
15	NC 177-16-30	26.31	54.60
16	M-19cc	26.00	51.39
G. arboreum			
1.	Nanded Buri	32.55	47.27
2.	Gaorani	31.45	54.74
3.	LS - 1	30.25	51.48
4.	Gaorani -20	30.05	47.92

It is evident from Table 7 that a sizeable diversity is available in terms of oil quality and a suitable sketching of apt breeding strategy and its execution would enable researchers to bring about an improvement in oil quality in those lines where unsaturated fatty acid profile is below average.

3.5.1 Conventional.Approach for Quality Improvement

The processing of cottonseed in the oil and meal industries has howsoever received little attention from an applied cotton improvement perspective. Since, cotton is a widely used oil seed there is a potential merit in modifying its fatty acid profile through enhanced breeding and biotechnological efforts. The importance of cottonseed oil in human nutrition is increasing and the demand for this valuable commodity is rising owing to some extent to a general shortage in supply of edible oils. Thus genetic improvement of cottonseed oil quality could be taken as the next important goal in cotton breeding (Joshi, 1995). Important breeding objectives in an oil improvement programme in cotton could be:

- To increase the cottonseed oil content
- To increase the polyunsaturated fatty acid and tocopherol contents in cottonseed oil.
- To decrease or eliminate the gossypol content in cottonseed oil.
- To decrease cyclopropane free fatty acid content in cottonseed oil.

In the past Ermakov (1976) has described methods and possibilities for improving the qualitative composition of cottonseed oil based on his experiments conducted during 1969-71 at Central Asian station of Institute of plant Industry (VIR), Uzbekistan. In his study, he reported hybrid between cultivated species and wild species, exceeded both the parents for saturated fatty acid contents.

3.5.2 Biotechnology for Oil Quality Improvement

Increasing oil content and quality: Improving quality of oil involves reduction of saturated fatty acid contents and there is a scope for biotechnology again. It could be possible with the further efforts to enhance the production of long chain polyunsaturated fatty acids with reduction in palmitic and stearic acid content, and an increase in oleic acid content for improving functional and shelf life properties.

Making Cottonseed Oil Healthier: Cottonseed oil is extensively used in food industry for several purposes but it is generally subjected to hydrogenation, which renders it stable during cooking at high temperature and, also softens and provide *mouth feel* in baked products. But hydrogenation leads to production of *trans fatty* acids also in some amount, which are health hazards and raise the cholesterol level in the blood. To produce naturally hydrogenated cottonseed oil free from *trans fatty* acids, scientists at Plant Industry Division, CSIRO, Australia have reintroduced a small amount of cotton's own DNA into its genome to *switch off the gene* which converts monounsaturates to polyunsaturates (ICAC Recorder, 2001). This results in cottonseed oil with high level of polyunsaturated fatty acid and, hence, avoiding any need for hydrogenation.

Gossypol free Cotton: The annual worldwide cottonseed yield could supply the dietary protein needs of some 240 350 million people, but presence of *Gossypol* is a major deterrent. Ruminant animals could tolerate the *Gossypol*, but it is toxic to non-ruminants. If *Gossypol* were not present, cottonseed oil could be made more economically and cottonseed meal could be processed for food and feed. The use of glandless cotton could produce *Gossypol* free cottonseed, but then insect predation would be a big menace. To keep *Gossypol* in plant but away from seed Ow (2000) proposed engineering the seed specific breakdown of *Gossypol*. He reasoned that *Gossypol* in cottonseed, like all organic matter must get recycled into the basic building blocks and that would mean there should be microbial enzymes that breakdown this compound. He identified an enzyme that could degrade the *Gossypol*, which ultimately led to the gene and construct for expression in plants. His group has been able to produce *transgenics* in which size and density of *Gossypol* containing glands were reduced in leaves and they have to further concentrate their work on getting the gene expressed in seeds, which would be the ultimate goal.

4.0 Cottonseed oil products and uses

Cottonseed cooking oil has a bland, neutral flavour. It is ideal for frying. Cottonseed oil is recommended for cooking, salad dressings and mayonnaise applications. New refining technology has made it possible to produce oil products "custom made" to satisfy almost any commercial need. High quality Cottonseed Cooking oil meets the requirements of almost any food application imaginable. Blended with other fats and oils, Cottonseed oil will improve their quality and functionality. Since Cottonseed cooking oil is naturally stable, hydrogenation is not necessary for most uses. Therefore it is free of trans fatty acids. Cottonseed oil is primarily used in the U.S. as a salad or cooking oil. About 56% is consumed in that category while about 36% goes into baking and frying fats, and a small amount into margarine and other uses. In India entire cottonseed oil produced is utilised for edible purposes, mostly for *vanaspati*, only small quantity (5-10%) is used for manufacturing soaps. Cottonseed oil can be used in all kinds of food manufacturing applications and can be customised to fit unique needs (Table 8 & 9).

Table 8: Cottonseed oil and food manufacturing applications

Use	Remark
Deep frying	Cottonseed oil is an excellent flavour carrier and enhances rather than masks the fresh, natural flavours of foods.
Baking	Blending of fully hydrogenated cottonseed oil with a partially hydrogenated base stock creates a shortening with a solid fat index that achieves an optimum plasticity for baked goods.
Margarines, icings and whipped toppings	Cottonseed oil is noted for its ability to form the beta prime crystal, which helps promote the desired consistent texture and smooth, creamy appearance in shortenings, toppings and spreads.

Salad dressings	Excellent choice for salad dressings owing to its neutral flavour profile and the fact that it can be winterised - a necessity for mayonnaise and commercial flavoured dressings. Dressings made with cottonseed oil resist oxidation well.

Table 9: New Dishes using cottonseed oil as a base

Uses in New Dishes	Remark
Fish and Seafood	These delicate flavours go along well with Cottonseed oil.
In hot spicy recipes	It can deliver the heat and spice of intensely flavoured foods.
Chinese cuisine	As cottonseed oil helps keep true flavours, it is an excellent choice for stir fried noodle dishes.

Cottonseed oil can be used in several other non-conventional ways also (Table 10).

Table 10: Non conventional products from cottonseed oil

Non Conventional Uses	Remark
Brominated Oils	These could be produced using cottonseed oil by adding bromine at low temperature with regular mixing.
Fat for Intravenous Nutrition	Emulsified cottonseed oil can be used as intravenous nutrition for patients requiring high calorie diet.
As Tallow Substitute	Cottonseed oil could be hydrogenated to a tallow like product to curtail the import of tallow for soap making and textile sizing.

4.1 Cottonseed oil - cooking tips

There are certain precautions, which should be followed for better utilisation of cottonseed oil for cooking;

Storage: It is wise to only buy a container size that one will use over a couple of months. Store oil in a tightly sealed container in a cool, dark location.

Cooking Temperature: Do not allow the oil to exceed 193°C (380°F) during frying, and preferably a temperature of about 182°C (360°F) should be maintained. On the other hand, if the temperature is too low, the food will have a greasy or oily texture.

Avoid Copper: Another important tip is to avoid the use of copper. Even the minutest particles of copper will cause the oil to deteriorate rapidly. This is true for all fats and oils.

Minimize exposure to ultraviolet (UV) light: Ultraviolet light will catalyze the degradation of triglycerides. UV light attacks double bonds in the unsaturated fatty acids producing by-products, which can act as pro-oxidant materials. These can lead to undesirable off-flavor and can compromise shelf life.

Filter regularly: Particulates from fried foods can darken oil, contribute bitter flavor to food, impede heat transfer, and ruin the appearance of foods.

5.0 Cottonseed Processing

Though cotton cultivation could be traced back to prehistoric times, cottonseed processing is of much recent origin. Cottonseed processing industry made its beginnings with the invention of the cotton gin in 1793, that led to the availability of large supplies of cottonseed possible, but it was in the early twentieth century only that cottonseed was utilised in commercial quantities for production of oil and other cottonseed products. In India traditionally, the cottonseed utilisation has been as an animal feed and it was in 1914 that Indian Oil Company established the first cottonseed oil mill at Navsari. Since then the Indian cottonseed oil industry has come a long way.

Cottonseed Production and Availability for Processing

	2001-2002	2000-2001
1. Cotton Production (Lakh bales)	158	140
2. Cottonseed Production (@333Kg/bale) (Lakh tonnes)	52.62	46.62
3. Retained for sowing & Direct Consumption (Lakh tonnes)	11.30	10.00
4. Marketable Surplus (Lakh tonnes)	41.32	36.62
5. Production of Washed Cottonseed Oil. (Lakh tonnes)	4.13	3.66

Source: 42nd Annual Report and Accounts 2001-02, All India Cottonseed Crushers' Association, Mumbai

5.1 Scientific *vis* a *vis* Traditional Processing

Cottonseed could either be processed by the traditional crude method of crushing seed without delinting in undecorticated form or by scientific processing of cottonseed, which involves removal of linters, decortication, separation of hull, expelling, solvent extraction and refining of oil. Scientific processing results in extraction of nearly entire cottonseed oil, while the oil cake obtained by traditional method still contains about 7% residual oil. This high residual oil is not required by the animals but ironically much in demand because of misconception among the dairymen. The cottonseed meal obtained through scientific method contains negligible oil and has very high by-pass type protein content of 40 to 42%. In international market trading takes place for cottonseed extraction only and not for undecorticated cottonseed oilcake, but in India it's the latter that calls the shots. In India the major reason for non-adoption of scientific processing rests on economics. Net return from scientific processing of cottonseed is negative in comparison to traditional method. This negative net return for scientific processing could be attributed to both high demand and thus the higher price for undecorticated cake and falling export of cottonseed extract. On export front too situation is not very encouraging, there has not been any export of cottonseed extract since 1997-98. This downslide has been caused by very low or no oil in cottonseed extract rendering it unattractive as cattle feed and also by high cost of decortication at domestic level making it uncompetitive in international market.

5.2 Cottonseed Oil Processing and Keeping quality Improvement

To address problems associated with oil extraction and long term keeping quality research work, under Technology Mission on Cotton, is in progress at Central Institute for Research on Cotton Technology (CIRCOT), Mumbai to develop efficient oil extraction protocols and also to test their techno-economic feasibility. Efforts are being made to identify suitable antifoaming agent along with its optimum concentration for preserving quality of frying oil for longer duration under Indian cooking habits. To create awareness and to promote widespread consumption, work is being carried out towards exploring novel culinary applications also.

5.3 Cottonseed oil- refining

Cottonseed oil obtained from solvent extraction is crude oil. Figure 11, gives an idea about various steps involved in extracting cottonseed oil through scientific method. The crude oil contains varying levels of non-triglyceride materials, the majority of which would be considered impurities in most finished oils.

Oil, which is sold to food processors and at the retail level is fully refined, that is, it has been processed to remove most impurities or non-triglyceride materials. The level to which a particular oil is refined also depends on the purpose for which it is refined and mayor may not involve all the treatments given during refining.

Table 11: Various steps involved in refining the cottonseed oil

Process	Purpose	Procedure and Chemical Reaction	Remarks
Alkali Refining	Removes free fatty acids, glycerol, carbohydrates, resins, metals, phosphatides and protein meal.	The oil and alkali are mixed allowing free fatty acids and alkali to form a soap. The resulting soapstock is removed through centrifuging Cottonseed oil is also refined using a process called miscella refining.	The oil produced thus has a lighter, more desirable colour.
Bleaching	Eliminates trace metals and other colour bodies.	Bleaching clays are used, which adsorb the impurities.	Bleached oils are nearly colourless and have a peroxide value of near zero.
Winterisation	Cottonseed oil destined to be used as salad oil is winterised so that it will not become cloudy when chilled.	Oil is chilled with gentle agitation, which causes higher melting fractions to precipitate. The fraction which settles out is called stearin.	
Hydrogenation	Hydrogenation produces oil with the mouth feel, stability, melting point and lubricating qualities necessary to meet the needs of manufacturers.	Treatment of oil with hydrogen gas in the presence of a catalyst results in the addition of hydrogen to the carbon-carbon double bond.	It is a selective process that can be collntolled to produce various levels of hardening, from very slight to almost solid.

Deodorization	It removes volatile compounds from the oil, the end product is a bland oil with a low level of free fatty acids and a zero peroxide value. This step also removes any residual pesticides or metabolites that might be present.	Deodorization is a steam distillation process carried out under a vacuum. Cottonseed oil as it can be deodorized at lower temperatures, which results in more tocopherols (natural antioxidants) being retained.	Deodorization produces some of the purest food products available to consumers. Few other products are so thoroughly clean as refined, bleached and deodorized oil.
Interesterification	To rearrange or redistribute fatty acids on the glycerol backbone It can improve the functional properties of the oil.	This is most often accomplished by catalytic methods at low temperatures. The oil is heated, agitated and mixed with the catalyst at 90°C. There also are enzymatic systems which may be used for interesterification.	It does not change the degree of saturation or isomeric state of the fatty acids.

5.4 Cottonseed oil - grades

It has been found that variability exists for colour, free fatty acid (FFA), gossypol and odour among the cottonseed oils even when extracted from same variety through different processes. Marked variation in composition of oil for the same variety has been noticed when processed by different mills using same procedure. This has led to the development of suitable grades to identify cottonseed oil based on its grade. The first Indian Standard for cottonseed oil was IS: 543-1954, which was later revised in 1966 and then in 1968 as IS: 543-1968. This standard included four grades of expressed oil and solvent extracted oil each. Table 12 describes various standard values for these grades:

Table 12: Bureau of Indian Standards (BIS): Requirement for cottonseed oil IS: 543:1968

Characteristic	Expressed				Solvent Extracted			
	Refined grade	Grade IA (washed)	Grade IB (washed)	Grade 2 (raw)	Refined grade	Semi Refined (raw)	Grade IB	Grade 2 (raw)
Moisture and insoluble impurities % by wt. Max.	0.10	0.10	0.10	0.25	0.10	0.25	0.75	1.5
Lovibond colour (Y –I0R), not deeper than								
a. original oil	10	25	35	-	14	35	-	-
b. bleached oil	-	8	15	-	-	15	-	-
Refractive index at 40°C	1.4630 to 1.4660							
Specific Gravity at 30°C	0.910 to 0.920							
Saponification Value	190 to 198							
Iodine value (Wijs)	98 to 110							
Acid Value max.	0.3	0.5	0.5	10.0	0.3	0.75	10.0	25.0
Unsaponifiable	1.5	1.5	1.5	20	1.5	1.5	2.0	2.5
matter, % by wt. max.								

Refining loss, % by wt. max.	-	-	-	15.0	-	-	15.0	40.0
Flash -point, Pensky-Martens (closed, 0°C, min.)	-	-	-	-	250	125	100	90

Refined grades of oil are directly edible. All other grades except grade 2 (raw) are used for production of *vanaspati* and refined oil. Grade 2 (raw) oil is utilised for industrial purposes.

---- End of the reports ----

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