



Significance of scientific processing of cottonseed in cotton value chain

V. G. ARUDE*

ICAR-Central Institute for Research on Cotton Technology, Mumbai - 400019

**Email: arudev@gmail.com*

Abstract : Cottonseed is an important by-product in cotton value chain. At present only about 5 per cent of the cottonseed is processed scientifically. Estimated loss in value of by-products due to traditional processing is worked out to be Rs. 6800/ton of cottonseed. It is due to loss of important by products such as oil, linters and hulls. It is estimated that India loses average worth about Rs. 8075 crores annually due to the traditional processing of cottonseed. Shortage in domestic requirement of vegetable oil could be make up through promoting scientific cottonseed processing which would provide additional supply of around 7 lakh tonnes of cottonseed oil. Deoiled cake obtained after extraction of the oil is an important protein source (40 to 42%) for animal feed. Microbial/ chemical degossypolisation technology can open the application of deoiled cake for poultry and aqua-feed markets and perhaps for human food also and can thus make the scientific processing more attractive. High cost of initial investment, energy intensive delinting and decorticating operations and high cost of production of linters and deoiled cake are the factors that contribute to slow progress of scientific processing of cottonseed. There is need to accelerate the shifting towards scientific cottonseed processing in the larger interest of the nation. It can be achieved through certain measures such as mission mode approach for scientific cottonseed processing, adoption of Chinese pattern of delinting cottonseed, utilization of deoiled cake in compound cattle feed, special package for upgradation of cottonseed processing industry and creation of awareness among stakeholders about cottonseed by-products. Besides this cotton crop should be included under oilseed crops. Sustainable development in cotton sector can be achieved through adoption and promotion of viable technology based industrial applications of cotton by products. It would increase the value realized from cotton crop, which would in turn benefit the country and all stakeholders in the cotton value chain.

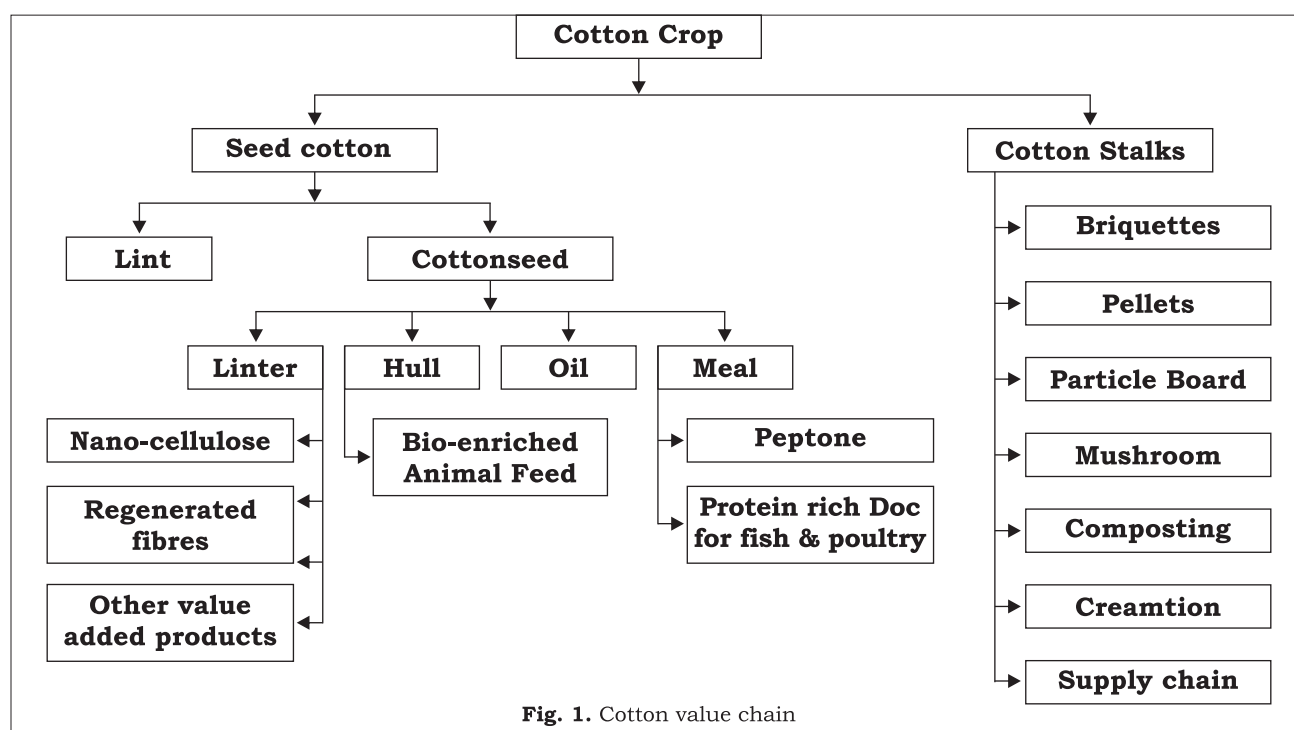
Keywords: By products, cottonseed, scientific processing, value addition

Cotton Value Chain

Cotton is an important fibre crop of global significance. India ranks first in production by contribution of 26.13 per cent of total world production *i.e.* 6.3 million tonnes for the year 2021-2022. Cotton is cultivated mainly for its fibre which is the most important commercial product apart from the cottonseed and cotton stalks. Cotton fibre is the principal raw material for a flourishing textile industry in the world. Despite the advent of multitude of other fibres, king cotton rules the world of textiles and enjoys the prime position as an apparel fabric due to its wear comfort. It is one of the important commercial crops, playing a key role in the economic, social and political affairs of the world. It has hundreds of uses, from jeans to shoe

strings, clothing to household items and the industrial products. The demand for cotton will exist as long as civilizations exists. Cotton based industry is an employment oriented industry (Patil *et al.*, 2018). In a global market economy, cotton is one of the few commodities that every nation desires to possess. Cotton brings prosperity to richest nations and also brings food security for the poorest countries (Kranti, 2011).

Cotton stalk is an important by product finds its applications in making value added products such as briquettes, pellets, particle boards, cultivating mushrooms and preparation of compost. Cottonseed is another important by-product which is a rich source of food because of edible oil and cottonseed meal. Data in Table 1 shows the estimated availability of cottonseed



from 2015-2016 onwards. Cottonseed oil finds extensive applications across various industries. It is mainly used as cattle feed and to re-harvest fields. Linters, the short fuzz on the seed provides cellulose for making various products like plastics, explosives and high quality paper. Cottonseed hulls used for extraction of furfural, an industrially important chemical. It is a good roughage and commonly used in feed lot and dairy rations. However due importance is not be given to cottonseed in the cotton value chain (Fig. 1).

Cottonseed the 'Golden Goose'

India is emerged as the largest producer of cotton in the world, against this backdrop cottonseed (Fig. 2) processing has assumed

significance. The cottonseed is the 2/3rd portion of seed cotton. India produces around 12.5 million tonnes of cottonseed annually which has so far been considered as secondary product or byproduct of cotton lint and not given due importance. Cottonseed has traditionally been considered as cattle feed however in recent time multiple uses to maximize the value generation from cottonseed have been developed.

Cottonseed is considered as golden goose, since all the parts of cottonseed are used as food, feed and other valuable products. When the cottonseed moves from the gin to a cottonseed oil mill, it is made up of three parts *i.e.* linters, which are short fibres still clinging to the seed; hulls a tough protective covering to the

Table 1. Estimated availability of cottonseed in India

Year	Area (Lakh hectares)	Cotton production (Lakh bales of 170 kg each)	Cottonseed production (@333 kg per bale, Lakh Tonnes)
2015-2016	122.92	332.00	110.55
2016-2017	108.26	345.00	114.88
2017-2018	125.86	370.00	124.21
2018-2019	126.14	333.00	110.89
2019-2020	134.77	365.00	121.54
2020-2021 (P)	132.85	352.48	117.22
2021-2022 (P)	120.69	340.62	113.42



Fig.2. Cottonseed

kernel and the protein and oil rich kernel. Table 2 depicts the country wise estimated availability of cottonseeds, hulls and hinters for the year 2020-2021. Cottonseed contains around 18 per cent oil and 25 per cent protein. The cottonseed meal is rich in essential amino acids and it is an important animal feed. Besides yielding wholesome oil, branded as 'Heart Oil', it yields other valuable by products like linters, hulls and cottonseed extraction. However, a fairly large portion of oil and almost the entire quantity of by products like linters, hulls are lost due to processing of cottonseed through the traditional method.

Traditional cottonseed processing

More than 95 per cent of cottonseed is presently processed by traditional method. It involves simple mechanical crushing of the cottonseed by screw expeller to produce oil and cake (Fig. 3). The oil cake contains all the non nutritional material *i.e.*; linter, hull, oil and dust *etc.* Besides the oil cake is low in protein content. All the value added products gets mixed in the oil cake. This oil cake finds application only to dairy cattle's. The traditional uses of cottonseed comprises of feeding whole cotton seed to cattle, use of cottonseed after processing for sowing, processing to obtain oil and oil cake and use of oil cake for oil extraction and de oiled cake.

There are about 2,000 processing units in the country. Due to this primitive nature of processing, not only the oil yield is low about 10 per cent but it is of the inferior quality and 6-7 per cent of residual oil cannot be extracted, which becomes part of the oil cake. This is serious limitation of the traditional process.

This high residual oil is not required by the animal but it is much in demand because of misconception among the dairymen. The cottonseed cake obtained through traditional method contains about 20 to 22 per cent protein which is very low as compared to around 40 to 42 per cent in scientific processing of cottonseed. It is fact that the cattle only need to have more protein in meal not oil (Savanam *et. al.*, 2011). Around 125 lakh tonnes of cottonseed is produced during 2021-2022 out of that about 95 per cent (118.75 lakh tonnes) can be made available for scientific processing.

Table 3 depicts the estimated loss in value of by products per ton of cottonseed due to traditional processing as compared to scientific processing with production of degosspolised meal. Feeding traditionally prepared undecorticated cake (UD) to cattle with oil content as high as 6 per cent virtually amounts wastage of more than 7 lakh tonnes of cottonseed oil every year. Traditional processing loses linters worth about Rs. 2000 crores, hulls valued at about Rs. 3000 crores every year. In traditional processing residual oil, linters and hull gets mixed with meal to form UDC. Estimated loss in value of by products per ton of cottonseed due to traditional processing is worked out to be Rs. 6800. However it is observed that UDC fetches higher prices than DOC without degosspollisation. It is estimated that India loses average worth about Rs. 8075 crores annually due to the traditional processing of cottonseed (Table 4). It is therefore, considered essential to shift from traditional to scientific processing of cottonseed in the larger interest of the nation.

Table 2. Estimated availability of cottonseeds, hulls and linters (2020-2021)

1	India	12525	2255	4384	689
2	China	11569	2082	4049	636
3	US	8455	1522	2959	465
4	Brazil	5690	1024	1992	313
5	Pakistan	2633	474	922	145
6	Uzbekistan	1486	267	520	82
7	Turkey	1464	264	512	81
8	Greece	712	128	249	39
9	Mexico	667	120	233	37
10	Argentina	595	107	208	33
	Total	45796	8243	16029	2519

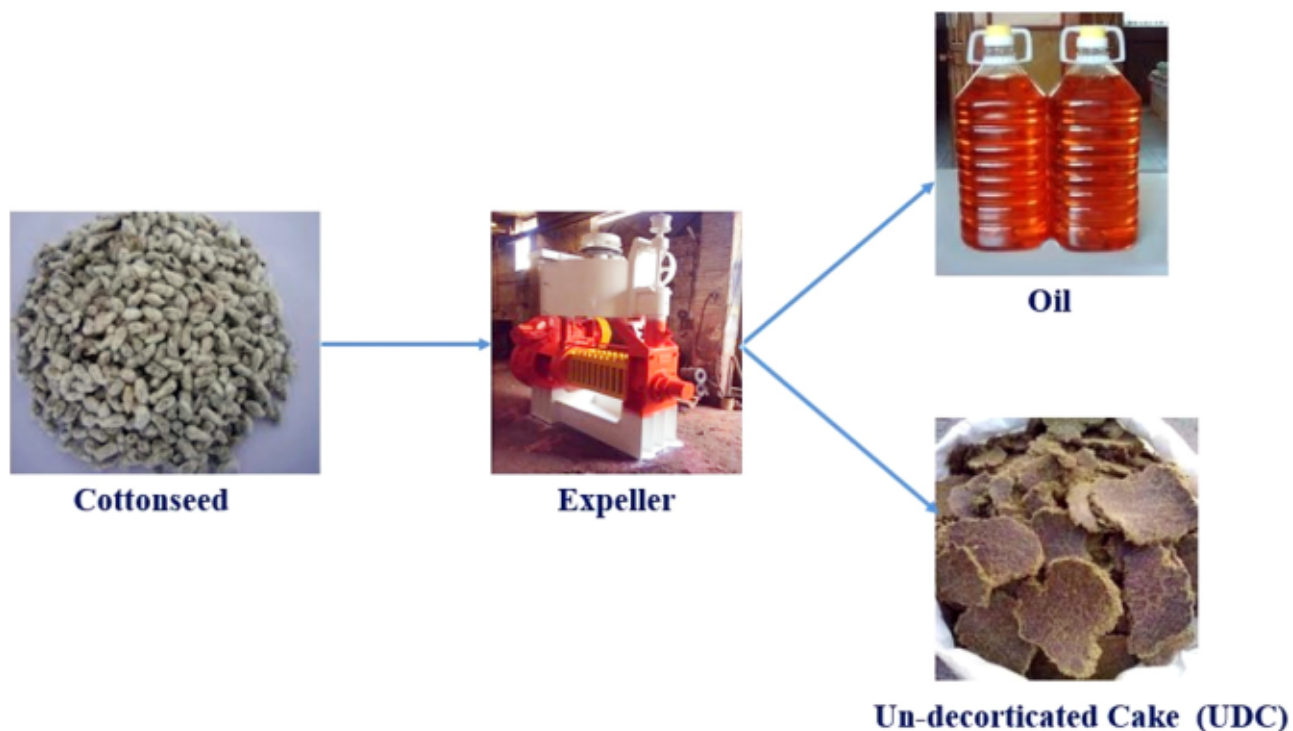
[Assumption: Cottonseed= 65% seed cotton; Oil=18% cottonseed; Hulls= 35% cottonseed; Linters= 5.5% cottonseed]

Scientific cottonseed processing

Scientific cottonseed processing involves, cleaning of cottonseed, removal of de-linters, and separation of hulls, oil expelling, solvent extraction and refining of oil. Scientific processing of cottonseed results in extraction of nearly entire cottonseed oil, while the oil cake obtained by traditional method still contains about 6 to 7 per cent residual oil. The cake obtained through scientific method contains protein content of around 40 to 42 per cent (Ferro Oiltek Pvt. Ltd.,

2022). Various steps involved in scientific cottonseed processing are depicted in Fig. 4.

Cleaning of cottonseed: In scientific processing of cottonseed, first cottonseed is cleaned through cottonseed cleaner where all impurities like unginned cotton and all types of foreign particle including plastics threads, pouches, small stones etc. are removed. If impurities are not removed it affect quality of oil and other by-products (Bohra, 2021). Cottonseed cleaning

**Fig. 3.** Traditional processing of cottonseed

also protects machinery from damage. Therefore cottonseed cleaning needs special attention. Efficient cottonseed cleaning could be achieved by cleaning cottonseed through rock and shale trap system followed by seed cleaner consisting of four vibrating trays. Rock and shale trap removes a large impurities like stones, metal debris, plastic papers and dust particles at the initial stage. Vibrating cleaner cleans light trash, loose fibre, shales, metal and sand. **Delinting:** Delinting is the process of removal of linters fuzzy portion left out on outer covering of seed after ginning. The short fibre which is there on the surface of the cottonseed are known as linters. There is around 5 to 6 per cent linters on the cottonseed. These are obtained mainly in two stages i.e. 1st cut and 2nd cut. First and second cut linters staple length lies between 5 to 10 mm and between 2 to 5 mm, respectively. Generally about 20 per cent of linter production is 1st cut, 70 per cent is 2nd cut and remaining 10 per cent is mill run cut. Delinting is performed either mechanically or by acid delinting (Sharma, 2014). In acid delinting; linters cannot be recovered. Hence to obtain valuable linters mechanical delinting process should preferably be carried out. Mechanical delinting process either performed by using saw type delinter or brush type delinter machine. Saw type delinting machines has high capacity as compared to

brush type delinting machines, hence mostly used in industry. In India, the extraction of cotton linters is about 90,000-100,000 tonnes, contributing less than 10 per cent of world production. In India, cotton linters are always in short supply and as a result it becomes unaffordable to small processors. This situation is essentially due to absence of scientific processing of cotton seed in large quantities. However it is reported that out of the available quantity, internationally, a very small fraction of the linters (say about 10%) is used for value addition, offering scope for its enhanced utilization (Sreenivasan, 2020).

Linter cleaning and baling: Linters need to be cleaned to remove small hulls, motes, dust and pepper trash that come along with linter during delinting process. Paddle beater type linter cleaners are employed by industry for linter cleaning. Properly cleaned linters fetches better prices. Linter quality is always measured by cellulose content and it should be periodically checked in Laboratories. It is a set parameter for getting better price. The cellulose recovery in 1st cut is around 75 - 80 per cent and in 2nd cut linters is around 70 - 77 per cent. Linters are pressed in the form of bale in the bale press for easy handling, transportation and marketing.

Table 3. Estimated loss in value of by-products per ton of cottonseed due to traditional processing

Particular	Recovery (%)	Quantity (kg)	Rate(Rs/ton)	Value (Rs.)
Traditional cottonseed processing				
Cottonseed Oil	10	100	120	12000
Cotton linters	Nil	Nil	NA	NA
Cotton hull	Nil	Nil	NA	NA
UDC (Oil cake)	85	850	30	25500
Total value/ton				37500
Scientific cottonseed processing				
Cottonseed Oil	16	120	120	14400
Cotton linter	5	50	40	2000
Cotton hulls	26	260	15	3900
DOC (Degossypolised)	48	480	50	24000
Total value/ton				44300
Loss due to traditional processing (Rs./ton)				6800

[Average Prices: Cottonseed Oil = Rs. 120/kg, Linter = Rs. 40/kg, Hulls = Rs. 15/kg, UDC oil cake = Rs. 30/kg, DOC (Degossypolised) = Rs. 50/kg (AICOSCA, 2022)] (Assumption: 5% loss during processing)

Table 4. Estimated national loss in value of cottonseed by-products due to traditional processing

Particulars	Value
Production of cottonseed, (Lakh tons/year)	125
Availability for scientific processing (95%), (Lakh tons/year)	118.75
Loss in value of by-products due to traditional processing, (Rs./ton)	6800
National loss due to traditional processing, (Rs. in Crores/year)	8075

Decortication/de hulling: It is the process of separation of outer covering hull from the kernel of delinted or un-delinted seed. It is essential to remove hulls otherwise it absorbs extracted oil thereby reducing oil yield. Basket hull beater with high speed separation mechanisms is employed for decortication. Hull is the seed coat which constitutes about 37 to 60 per cent of the weight of seed depending upon the variety and species. Hulls contain about 35 to 47 per cent of alpha cellulose, 19 to 27 per cent pentosans, 15 to 20 per cent lignin, 5 per cent ash, protein, fats, etc. (Balasubramanya *et al.*, 2007)

Oil expelling –cooking, flaking and expanding:

Cottonseed oil is extracted from the kernel, either by mechanical processes such as crushing or pressing, or by chemical processes such as solvent extraction. Cooking, flaking and expanding processes prepare the kernel to release oil for efficient extraction of oil. Expelling is mostly done with the screw type of expeller machine. Crude oil and expelled cake is obtained during the process of oil expelling.

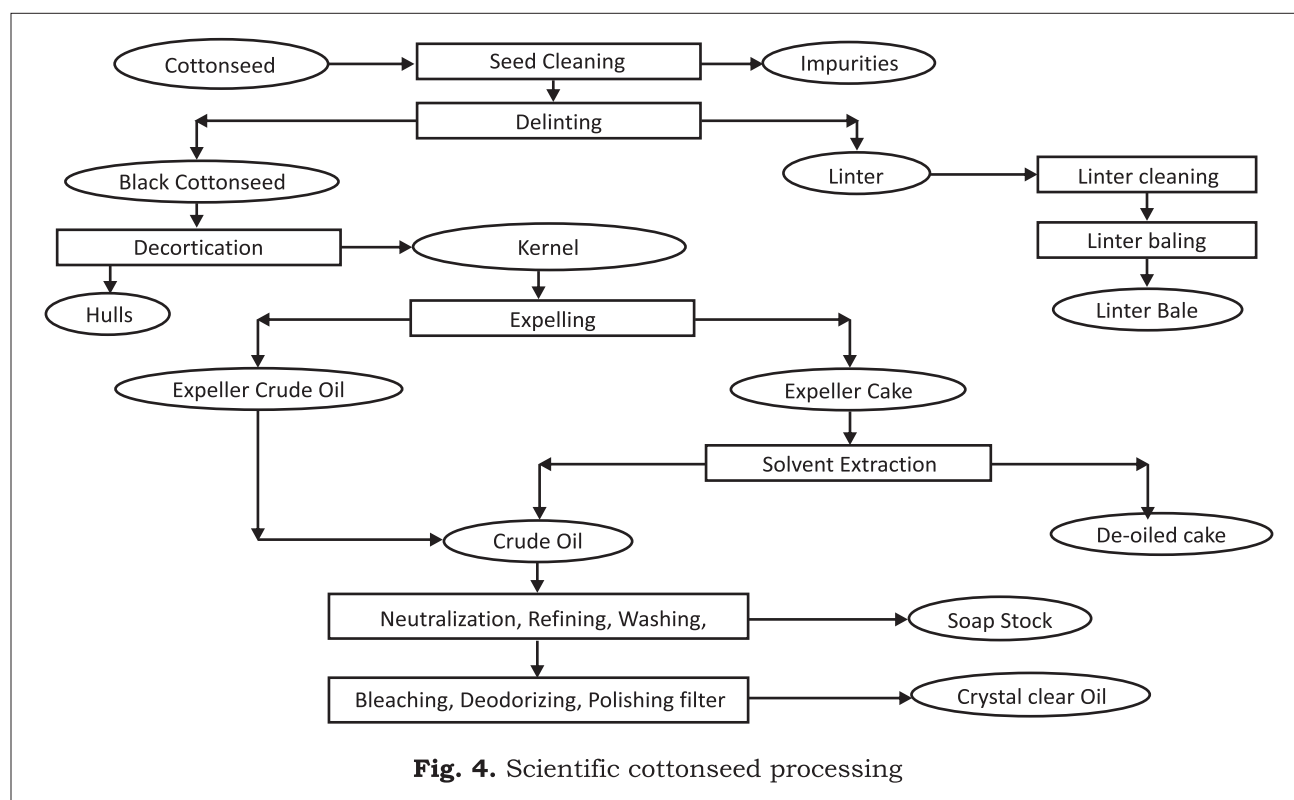
Solvent extraction: Cake obtained after expelling process is subjected to solvent extraction to remove the residual oil left in the cake to produce the de-oiled cake (DOC). DOC contains about 40 to 42 per cent protein, 10 to 12 per cent fibre, less than 1 per cent oil and moisture content more than 10 per cent. Cottonseed oil is most commonly extracted commercially *via* solvent extraction.

Refining: Crude oil obtained through expeller and after solvent extraction contains impurities. It need to be processed and refined before it can

be used for consumption. In order to remove impurities, including free fatty acids (FFA), phospholipids, pigments, odour, gums, and moisture and volatile compounds. Crude oil is subjected to neutralization, refining, washing, bleaching, de odourization and polishing filter to obtain crystal clear oil with enhanced grade. After refining process it contains less than 0.01 per cent FFA.

Degossypolised cottonseed protein (DGSCP):

The presence of gossypol limits the use of cottonseed DOC as feed for poultry and aqua. Feeding diets containing gossypol to animals would cause negative effects such as growth depression, reproductive disease and intestinal and other internal organ abnormalities. The presence of gossypol decreases the digestibility and reduces the nutritional value of cottonseed protein. ICAR-CIRCOT has developed microbial degossypolisation technology to produce protein rich cottonseed cake for non-ruminants but got limited success in reducing free gossypol (70-80%) and bound gossypol (50-60%) (Mageshwaran, 2019). Cotton Leader Biological Science and Technology Co., Ltd., Beijing, China has developed Degossypolized Cottonseed Production (DGSCP) Technology. Chinese patent was grated to soaking and repeating degossypolization technology for producing cottonseed protein which improved the digestibility and nutrition level of degossypolized cottonseed protein. The production process involves pre-cleaning of black cottonseed, decortication, low temperature softening, pressing, sheeting and drying and then solvent extraction. The de-oiled wet meal goes to degossypolizing extractor and gets extracted twice by solvent to make the



content of gossypol meet the process requirement. The solvent free wet meal is then dried at low temperature. Cottonseed protein is produced by low temperature degossypolization. Cottonseed protein so obtained by this process has the features of low fiber content, high metabolic energy and high lysine effective value. Degossypolized cottonseed protein can substitute soybean meal and fish meal to be widely used in feed industry. Cottonseed protein is a high grade protein ingredient in animal feed with its free gossypol being equal with or less than 50ppm and more than 50 per cent of protein. Its nutritive index is better than soybean meal, hence has been widely used in livestock feed and aquatic feed to partially replace vegetable and animal proteins such as soybean meal, corn protein powder and fish powder (China Leader Biological Science and Technology Co. Ltd., 2022).

Industrial applications of cottonseed By-products

Cottonseed produces food for man and feed for animals. Linter, cottonseed meal, hulls and oil are the important by-products of cottonseed which finds diversified applications in all spheres of life. Cottonseed value is determined by the value of the products produced. World vegetable oil markets and markets for livestock feed ingredients play a major role in determining the value of cottonseed.

Linter: Cotton linter has a very high alpha cellulose content. Cotton linter is a valuable and vital by-product for use within the country and for export also. Linters are used in the manufacture of fibre pulp for paper, absorbent cotton, and cellulose acetate for making plastics, films, manmade fibers, nano cellulose, cellulose esters and ethers for pharmaceuticals, cosmetics, paints, tooth paste, ice cream, lacquers, and salad dressing. It is also used for felts for automotive upholstery, pads, cushions,



Fig. 5. Pilot plant for scientific processing of cottonseed at GTC of ICAR-CIRCOT, Nagpur

furniture upholstery, mattresses and comforters etc. (Sharma, 2014). Since it is a prized raw material it is used for high grade bond, currency, low grammage tissues and filter paper. Bleached cotton linters are being used by ordnance factories for production of propellants, for smokeless gun powder, gun ammunition, cellulose nitrate for dynamite and also various missiles. Hence it has a huge export demand.

Deoiled cottonseed cake (DOC): Deoiled cottonseed cake (DOC) is produced as a result of scientific cotton processing. It contains high protein content (about 40 to 42 %) with almost nil oil content. As per Association of American Feed Control Officials (AAFCO) definition the de-oiled cake must not contain less than 36 per cent crude protein. It is a concentrated source of protein and energy for livestock. The cottonseed meal can be used as animal feed, preparation of peptone, filler for plastics and fertilizer ingredient. The high protein diet increases the milk production in the

milking cattle significantly. This product has huge demand in domestic markets and exports for animal feed industry. Cottonseed meal is the most abundant plant protein feed after soybean meal. However gossypol content is a limiting factor for the export of DOC. Degossypolisation technology to produce protein rich cottonseed cake for non ruminants is being developed and adopted to some extent. Once the gossypol content is controlled, cottonseed meal can also be used both as fish and poultry feed for which there is international demand. Increase in export of cottonseed meal will provide boost to scientific processing which in turn will reduce the recurring national loss of valuable by products including precious cottonseed oil.

Cottonseed hulls: Cottonseed hulls are used as roughages in cattle feed, mixing in special formulation of compound cattle feeds, petroleum drilling operations (mud additive), poultry litter, production of chemicals like furfural and for growing edible mushroom.



Cottonseed oil: Cottonseed oil refers to a vegetable oil derived from the cottonseeds and then refined to remove a naturally occurring toxin called gossypol. It contains high concentrations of Vitamin E, antioxidants, polyunsaturated fat, and fatty acids. It possesses anti inflammatory, anti aging, and moisturizing properties that are beneficial for skin health. It helps lower bad cholesterol, regulates blood pressure, improves heart health, and minimizes the risk of stroke. Cottonseed oil contains about 50 per cent essential poly unsaturated fatty acid against about 30 per cent in other oil which prevents coronary arteries from hardening. It is one of the few oils in American Heart Association's list of "OK FOOD". Cottonseed oil has many applications varying from medicinal to technical purposes. It finds extensive applications across various industries, including food processing, bakery and confectionary, cosmetics and personal care, detergents, and agriculture. Besides this, the increasing applications of cottonseed oil in cosmetics and personal care products, such as cleansers, lipsticks, and makeup products, due to its skin moisturizing properties. Cottonseed oil has a high level of natural antioxidants that contribute to its long fry life and long shelf life. It is widely used as cooking oil and adds moisture to baked goods. The other uses are for glycerol, lubricants, soap stocks etc.

India is facing a severe problem of shortage of vegetable oil. About 50 per cent of oil requirement is met through import. Even then oil prices are skyrocketing due to inadequate indigenous production and increasing trend of consumption. Annually about 6 lakh tonnes of cottonseed oil is being wasted from indigenous production due to nonscientific processing of cottonseed. It is important to note that, in India cottonseed oil still not recognized as an important source of edible oil in spite of the fact that it is contributing about 10 to 11 lakh tonnes

cottonseed oil every year. Further, the present level of oil production can easily be raised by about 40 per cent even with available raw material by application of modern processing technology. There is lack of effort by the policy makers and extension agencies and hence unable to prevent these losses.

Reasons for slow progress of scientific processing of cottonseed

Many factors contribute to slow progress of scientific cottonseed processing in India. The important points are highlighted below.

- Delinting and decorticating are energy intensive operations
- High cost of production of de-oiled cake and refined oil
- High initial cost of investment for scientific cottonseed processing
- Preference of cattle feeders to undecorticated cake (UDC) over de-oiled cake (DOC)
- Cottonseed cake is not sold on the basis of protein content unlike in foreign countries
- Fluctuations in prices of linters
- Lack of awareness among stakeholders about valuable cottonseed by products

Interventions to accelerate shifting towards scientific cottonseed processing

Mission mode approach for scientific cottonseed processing: It is evident that cottonseed is completely out of the ambit of development plan, either of the Government of India or the State Governments. Cotton crop should be included under oilseed crops and cottonseed oil should be considered as a main product and edible oil from the cotton crop. The Technology Mission on Oilseeds and Pulses (TMOP) and the Technology Mission on Cotton (TMC) for modernization of ginning and pressing factories; the two important development arms of the government had not included cottonseed in

their development plans. Government can make it mandatory to crush cottonseed scientifically to get maximum oil and recover by products. Hence it is utmost important to develop a mission mode programme exclusively for promotion of scientific cottonseed processing.

Adoption of Chinese pattern of delinting

cottonseed: In China, it is reported that ginning and delinting is followed in the same processing unit where as in India, ginning and processing of cottonseed are two separate entities. Adoption of this Chinese pattern on priority basis would save huge loss of cotton linters incurred every year. This practice would not only yields a large quantity of linters but also better quality of oil as well as higher recovery of oil. Besides this huge amount of money spent on transportation of undelinted cottonseed from ginning unit to cottonseed processing unit would be saved. It is known fact that bulk density of undelinted cottonseed is about 40 per cent more than the delinted cottonseed. Thus, about 40 per cent more seeds could be transported and stored in the same area if delinted. Besides this cotton linters can also be pressed by the same baling press used for pressing cotton lint and may thereby provide additional work to the ginning and pressing factories which have a short span of working. Hence it appears to be feasible to adopt the practice of delinting seed after ginning of cotton to reap the above benefits.

Utilization of deoiled cake in compound cattle

feed: Traditional cattle feeds are being replaced by the nutritionally balanced compound cattle feeds. The compound feed manufacturers should use larger quantities of proteinous cottonseed deoiled cake in manufacture of compound cattle feed, fish feed and also poultry feed. It would encourage scientific processing of cottonseed and thereby reduce enormous national losses of cottonseed by-products caused by traditional processing.

Special package for upgradation of cottonseed processing industry:

Most of the cottonseed processed in the country is through traditional ghani or expeller. Machinery used even where cottonseed is processed in a scientific manner is also quite old and inefficient. Delinting and dehulling are two important steps in processing cottonseed in a scientific manner. Industry is urging government for special package to help the industry to upgrade its technology and infrastructure. This would encourage scientific processing of cottonseed. It is the high time that the government pays due attention and comes up with some concrete package that can help this industry upgrade its base in terms of technology. There is need for a comprehensive policy framework, which can address the various issues of the processing industry in a time-bound manner. It would help the cotton farmers to boost their overall income from the cotton production, which is facing tough competition from other crops.

Research on cottonseed and its processing:

Most of the research work in public and private sector has so far been confined to cotton lint. The specific aspects which require research are for increase in cottonseed yield per hectare, increase in oil percentage, and reduction in gossypol content, increase in protein percentage, improvement in energy efficiency of delinting and decorticating machines, research on technology degossypolisation of cottonseed, and techno-economic feasibility studies of scientific processing of cottonseed.

Creation of awareness among stakeholders about cottonseed by products:

Due to lack of awareness, a large portion of the by-products are left unused. Hence there is need to form a right kind of ecosystem to create much needed awareness about the benefits of various components of cottonseed, including oil among various stakeholders of the value chain. AICOSCA has formed a development fund to

propagate scientific processing of cottonseed. But they support from state and central government extension agencies and cotton research institutions across the country.

CONCLUSIONS

There is need to accelerate the shifting towards scientific cottonseed processing in the larger interest of the nation as it would prevent annual loss of worth Rs. 8075 crores that is occurring due to non recovery of important by-products such as linters, hulls and residual oil in traditional way of processing. Scientific processing would provide additional supply of around 7 lakh tonnes of cottonseed oil and protein rich (40 to 42%) deoiled cake for animal feed. Degossy polisation technology has huge potential for application of deoiled cake for poultry and aqua-feed markets and perhaps for human food. Slow progress of scientific processing of cottonseed is due to high cost of initial investment, energy intensive delinting and decorticating operations and high cost of production of linters and deoiled cake. Measures such as mission mode approach for scientific cottonseed processing, adoption of Chinese pattern of delinting cottonseed, utilization of deoiled cake in compound cattle feed, special package for upgradation of cottonseed processing industry and creation of awareness among stakeholders about cottonseed by products would accelerate scientific processing of cottonseed. Sustainable development in cotton value chain can be achieved through adoption and promotion of viable technology based industrial applications of cotton by-products.

REFERENCES

- Balasubramanya, R. H., Shaikh, A. J., 2007.** Utilization of cotton seed byproducts: Model Training Course on ELS, CICR, Coimbatore India, 130-38, www.cicr.org.in.
- Kranti, K. R., 2011.** CICR: Spearheading cotton research in India, Paper presented in 5th World Cotton Research Conference, Mumbai, India, *Souvenir*, 16-25.
- Savanam, C.S., Bhaskara Rao, V.K., 2011.** Scientific processing and estimated losses due to traditional processing of cottonseed. *The Indian J. Comm.* **64** : 85-95.
- Sharma, M. K., 2014.** New trends in cotton ginning & cotton seed processing. Paper presented at 6th Meeting of the Asian Cotton Research and Development Network, Dhaka, Bangladesh.
- Patil, P. G., Sundaramoorthy, C., Mandhyan, P. K., Kranthi, K. R., 2018.** Sustainable practices in small scale cotton production, hand picking, fibre processing, and by product utilization Case studies from India, *ICAC Recorder*, **36** : 6-12.
- Mageshwaran, V., 2019.** Degossypolization of cottonseed meal. Paper presented in an International workshop on 'Promoting by products in Eastern and Southern Africa' Nagpur.
- Sreenivasan, S., 2020.** Value addition to linters. *The ICAC Recorder*, **38** : 8-16.
- Bohra, R. 2021.** Indian Cotton Linters- Quality Issues. Paper presented in webinar on 'Cotton Linters: Current scenario and future prospects' organized by ICAR-CIRCOT, Indian Society for Cotton Improvement (ISCI), and All-Indian Cottonseed Crushers Association (AICOSCA).

AICOSCA, 2022. All India Cottonseed Crushers Association (AICOSCA) News Letter, February 2022, 58-59.

China Leader Biological Science and Technology Co. Ltd., 2022. Leading the new directions of cottonseed processing. Retrieved from <http://storage.unitedwebnetwork.com/files/23/c85f0b8f53f97636135a016724200524.pdf>

Ferro Oiltek Pvt. Ltd., 2022. Cottonseed processing, oil extraction and refining plant. Retrieved from <https://ferrooiltek.com/cotton-seed-processing-oil.php>

Received for publication : December 1, 2022

Accepted for publication : December 22, 2022