Oilseeds Processing Technology

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FOREWORD

Though India produces about 18 million tonnes of oilseeds annually but still this level of production is not sufficient to meet the need of edible oil in the country. Hence, a continuous effort is on to boost the production of oilseeds utilizing the available resources The Technology Mission on Oilseeds (TMO), setup in May 1988 by the Government of India, is engaged in true sense to achieve the goa of having self-sufficiency in edible oil.

Together with improvement of pre-production technology and its application in increasing the production of oilseeds, equally important is to minimize the losses by adopting appropriate post harvest processing technology. The research work in post harvest processing technology on oilseeds is in scattered forms, hence not being properly utilized to obtain the essential benefit. The Central Institute of Agricultural Engineering (CIAE), Bhopal together with its other majo activities is also involved in R & D of processing technology of oilseeds. The scientists of this Institute have already brought out a book entitled "Post Harvest Technology of Oilseeds" which provides informations on available R & D work in India. This book entitled "Oilseeds Processing Technology" is the second publication in this series.

The book gives informations on 7 important oilseeds produced in India. All the technologies from threshing to value addition and by products utilization of oilseeds have been covered. The book is useful to scientists, researchers, field and extension workers, policy makers and others directly or indrectly interested in processing of oilseeds. The authors, Dr. B. D. Shukla, Dr. P. K. Srivastava and Er. R.K. Gupta have put a tremendons effort in compiling valuable informations, in the form of this book. I congratulate them for timely bringing out this publication.

01 August, 1992
Bhopal

NSL SRIVASTAVA
Director, CIAE

PREFACE

Edible oil is an essential commodity in India. A collective effort by the Government, policy makers, scientists, extension specialists, farmers, engineers and industrialists is being made to increase the production of edible oil to meet its requirement in the country. Oilseeds yield oil as well as other co-products and by-products. Deriving maximum value from the different coproducts and byproducts will help to maximize benefits to the consumers and return to the farmers. The post harvest system, therefore, has strong linkage with the technology of processing and marketing of oilseeds. Under the Technology Mission on Oilseeds (TMO), the Central Institute of Agricultural Engineering (CIAE), has given thrust to compile and publish the informations on economically viable and technically feasible technologies and equipment developed at the various research institutes and state agricultural universities (ASU) in India. In this area a book entitled "Post Harvest Technology of Oilseeds" has already been published by the CIAE and been found very useful. The present book entitled "Processing Teohnology of Oilseeds" is the second publication in the series under the TMO.

The book covers in depth all the available informations on processing of oilseeds starting from threshing to coproducts and by products processing and utilization of 7 major oilseeds grown in India. Different types of equipment and technologies developed and found suitable at various research organisations, institutes and SAU's have been described in detail. Oil expellers including the traditional as well as improved *ghanies* for processing of the oilseeds have been presented in the book with their drawing and discriptions considering the design and development aspects. Applications of research values for individual oilseeds have also been covered. Besides, the book also cover the economically viable and technically feasible technologies suitable for income and employment generation for rural people.

With all these informations we are sure that this book will be a valuable asset to researchers, engineers, scholars, students, manufacturers, extension workers, university professors and all those who are directly or indirectly involved in production and processing of oilseeds, its coproducts and byproducts.

We are thankful to all the scientists of post harvest group of CIAE, Bhopal who have provided informations of research value which have been included in this book. It is their contributions which have enabled us to bringout this publication. We are thankful to Dr. NSL Srivastava, officieating Director, CIAE, for providing necessary facilities in publishing this book. Dr. TP Ojha, Dy. Director General (Engg.), Indian Council of Agricultural Research (ICAR), New Delhi has been a motive force and provided necessary technical help. We are grateful to him. Help and encouragement rendered by Dr. NS Randhawa, Former Director General, Dr. MV Rao, Former Special Director General, Dr. G Singh, Asstt. Director General (Engg.) and Dr. Anwar Alam, Asstt. Director General (Agril. Engg.), of the ICAR, New Delhi are thankfully acknowledged. We thank to Mr. HS Srivas for designing the cover page, Mr. VG Bonde and Mr. V Natekar for drawing and tracing work and Mr. NG Bhandarkar, Mr. Mustafa Kamal and Mr. Mahipal Deshbhratar for typing the monuscript of the book.

Nevertheless, it is a combined effort of all the scientists of PHT group of CIAE and we thank them to all those who have directly or indirectly contributed in bringing out this publication.

August 15, 1992
Bhopal

BANSHI D SHUKLA
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NOTATIONS

AICRP	:	All India Coordinated Research Project
APAU	:	Andhra Pradesh Agricultural University
BIS	:	Bureau of Indian Standards
C	:	Celsius (centrigrade)
CFTRI	:	Central Food Technological Research Institute
CIAE	:	Central Institute of Agricultural Engineering
C : N	:	Carbon : Nitrogen
CTAE	:	College of Technology and Agricultural Engineering
Cal	:	Calory
cm	:	centimeter
DOC	:	Deoiled Cake
d	:	day
db	:	dry basis
dia	:	diameter
FFA	:	Free fatty acid
GAU	:	Gujarat Agricultural University
GBPUAT	:	Govind Ballabha Pant University of Agriculture and Technology
g	:	gramme
h	:	hour
HP/hp	:	Horse power
IARI	:	Indian Agricultural Research Institute
ICAR	:	Indian Council of Agricultural Research
IGSI	:	Indian Grain Storage Institute
IIT	:	Indian Institute of Technology
IRRI	:	International Rice Research Institute
JNKVV	:	Jawaharlal Nehru Krishi Vishwa Vidalaya
JNTU	:	Jawaharlal Nehru Technological University
K Cal	:	Kilo Calory
Kg	:	Kilo gramme
KJ	:	Kilo Joules

KVIC	:	Khadi and Village Industries Commission
Kw	:	Kilo Watt
LDPE	:	Low Density Polyethylene
MAU	:	Marathwada Agricultural University
MC	:	Moisture Content
Min/min	:	Minute
m	:	metre
mt	:	million tonnes
n-hexane	:	normal hexane (food grade)
OTRI	:	Oil Technological Research Institute
PAU	:	Punjab Agricultural University
PE	:	Polyethylene
PHTS	:	Post Harvest Technology Scheme
PKV	:	Punjab Rao Krishi Vidhyapeeth
PVC	:	Poly Vinyl Chloride
RAU	:	Rajasthan Agricultural University
RH/Rh	:	Relative humidity
Rs	:	Rupees
SEA	:	Solvent Extractor's Association of India
Sq	:	Square
TNAU	:	Tamil Nadu Agricultural University
t	:	tonne
temp	:	temperature
UAS	:	University of Agricultural Science
wb	:	wet basis

CONTENTS

1. INTRODUCTION

Fats and oils are one of the five essential ingredients of human diet and the others are protein, carbohydrates, minerals and vitamins. In a balanced diet, the oils and fats requirement per person per day is 35 g for vegetarians, 39 g for non-vegetarian and 38 g for average diet.

Oilseeds and animals are the main sources of fat. Though India has the largest number of animals compared to any single country of the world, but the animal fats are not preferred and our efforts to exploit fats of land and marine animals are negligible. The major responsibility of oil production in India, both for edible and industrial usages depends on vegetable oil seeds production. In the global context, India is one of the major producers of oilseeds which are the second major agricultural crop in terms of tonnage and value. In fact India enjoys a premier position in the world, occupying over 15 percent of its cropped area, accounting 10 percent of the total global output of the vegetable oils and fats.

The major oilseeds of India are groundnut, rape seed mustard, linseed, sesamum and castor. Groundnut and rape seed mustard account about 85 percent of the total production of oilseeds in the country. In other words, groundnut among the major oilseeds is accounted as about two-third, mustard seed one fourth of linseed and sesamum five perent of castor, and three percent of total production. Soybean, sunfower, safflower, cotton seed and coconut are the other important oilseeds produced in India.

For processing of oilseeds and oil bearing materials, India has a large network of oil mills employing more than 10 million people. Oil milling industries at present, consist of about 0.25 million village ghanies, 50,000 power driven ghanies, 50,000 mechanical expellers, 360 solvent extraction plants and 90 vanaspati units. The installed capacity of oil mills is estimated as 35 million tonnes per annum besides, there is solvent extraction plants of about 6.8 million tonnes per annum capacity in the country.

Inspite of a variety of oilseeds grown, other oil bearing materials produced, and a huge network of oilseed processing industry exists in the organised sector, shortfalls of oils in India has become a melancholy tale. Being an exporter of oil till 1964, it is a paradox that at present India has to import a big quantitiy of vegetable oils to meet her domestic need and thus spending about ten thousand million Rupees in terms of highly valued foreign exchange every year.

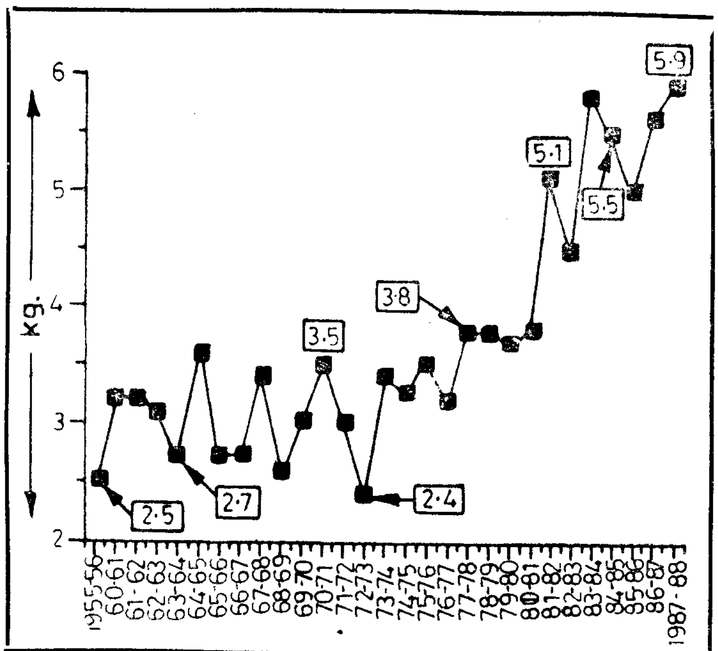


Fig. 1.1. Per capita availability of edible oils in India

The productivity of oilseeds in India is much less than several countries of the world. The oilseeds are cultivated in about 20 million hectares and 85 percent of the total acrage is under rainfed condition. The per capita availability of fats and oils in India is shown in Fig. 1.1. Thus the per head per day availability fats and oils in India workes out to be only 16 g as against the recommended level of

38 g/d/capita. This situation is indeed paradoxical as India is not only blessed with rich natural endowments but has a wide range of oil yielding species of plant origin too. However, it is true that the oilseed researchers have no miracle/wonder varieties to offer for stepping up the production at once.

According to estimates of Govt. of India, the country requires about 24 million tonnes of oilseeds equivalent to 6.6 million tonnes of oil per year by the turn of century as against the present production of 18 million tonnes. To bridge this gap and to make India self reliant in vegetable oils, it has become necessary to not only augment the resources for more production of oilseeds but also conserve the oilseeds and their products by proper processing. Most of our installed capacity of oilseed processing industries are extremely old and inefficient with high consumption of steam and power/energy and thus have low recoveries of oil. The quality of the products is also poor and large quantities of oil is left in the oilmeal. It is reported that not less than 0.5 million tonnes of oil of the value about ten thousand million Rupees is lost due to improper processing of oilseeds.

The seven major constraints : i) In-efficient processing (ii) inadequate utilization of some oil bearing materials such as rice bran, (iii) unscientific and inadequate storage, (iv) exploitation of oilseed based proteins, (v) inefficient and expensive packaging, (vi) inadequate research and development, and (vii) problems in exporting oilseed materials are the big hurdles in increasing oil yields in this country which need attention.

Various centres of All India Co-ordinated Scheme of ICAR on Post Harvest Technology and other research and development organisations have developed a good number of technologies for processing of oilseed and their products. Chapter 2 of the book describes, in short, the composition of oilseed and oils and their characteristics while chapter 3 reviews the various unit operations involved in post harvest technology of oilseeds. Cropwise informations on equipmnnt and technology developed for primary processing of seven major oilseeds products in India have been described in chapters 4 to 11. In chapter 12 a brief discussion on profitability and employment potential for primary processors using selected equipment has been presented. List of manufacturers of oilseed processing equipment and other involved agencies are mentioned in Appendix.

2. COMPOSITION AND CHARACTERISTICS OF OIL SEEDS AND OILS

A basic knowledge of composition of oil seeds and oils is essential to evolve a proper process of oil extraction. The present chapter describes these two important factors.

2.1 Seed Composition

Plants store the required food for their seedlings in the form of oil in their seeds. Thus the oil is used by the seedlings during germination and early growth. The oil content of the seed sustains the seedling until the leaves develop chlorophyll and start producing their own food by the process of photosynthesis. The mother plant takes sufficient care to see that the oil in the seed is properly protected from external influences. Oil is placed well spread in all the cells of the seed in very tiny ultramicroscopic droplets in the form of an emulsion. Each droplet is surrounded by the albuminoid cell matter composed of proteins and carbohydrates. The cell is again enveloped by a cell wall. Compact arrangements by all these cells and the hard seed coat provide futher protection to the oil droplets. To undo all these care taken by the mother plant is the first stage of oil extraction. The cells which are so compactly arranged are to be exposed, their walls ruptured and the oil droplet lodged inside is expelled. Table 2.1 describes the oil contents of various oil seeds produced in India.

Table : 2.1 Average oil contents of different oilseeds & oil bearing materials

Crop/oilseed/ oil bearing material	Oil content, %
Groundnut	28 (pods)
	40–44 (kernels)
	33 (seeds)
Rapeseed/mustard	33-41.5 (seeds
Soybean	19–21 (seeds)
Sunflower	37–42 (seeds)

Safflower	35-38 (seeds)
Sesamum	40-49 (seeds)
Linseed	33-42 (seeds)
Castor	-33-49 (seeds)
Coconut	60-68 (kernel)
Cotton	15-20 seed)
Niger	45-41 (seed)

Source : (i) Profile in Oil Technology, OTRI, Anantpur, 1978
(ii) Post Harvest Technology in India, CIAE, Bhopal, 1980

2.2 Seed Characteristics

In order to enable the best possible conditions for seed processing, storing and transportation, informations on their characteristics are needed. The important characteristics required in design and development of processing equipment are size, shape, bulk density, specific gravity, porosity, static coefficient of friction, angle of repose, rheological properties etc. Table 2.2 describes these characteristics for various oil seeds produced in India.

2.3 Composition of Oil and their Characteristics

Fats and oils are basically esters of glycerol and fatty acids, most of which have an even number of carbon atoms. The fatty acids found in the oils may be either saturated, i.e., each carbon atoms in the chain is linked by a single bond to other carbon atoms or to hydrogen atoms or they may be unsaturated having one or more carbon atoms in the chain joined by double bond.

The natural flavour and odour of oils are due to the presence of non-fatty matter. Their colour is due to the presence of small amounts of fat, soluble pigments such as cartoenoids and chlorophyll or sometimes due to oxidation and polymerisation products of the fatty acids.

Fat in the diet serves to increase the palatability and flavour of foods. They provide a lubricating action and delay the onset of hunger. They also improve the texture of food items. One gram of

Table 2.2 : Engineering characteristics of major oilseeds produced in India.

Oilseed & variety	M.C. % Wb	Length, mm	Breadth, mm	Thick-ness mm	Size, mm	Spheri-city	Poro-sity, %	Bulk den-sity, g/cc	Speci-fic gra-vity	Crush-ing load, Kg/ Kemer	Coeffi-cient of internal friction	Speci-fic heat, cal/g°C
Groundnut (pod)												
TM – 1	—	28.95	11.92	10.89	15.55	0.54	0.32	—	—	—	—	0.360
Pol - 1	—	38.70	11.00	10.70	16.58	0.43	0.32	—	—	—	—	—
Groundnut												
(Kemel)	7.0	15.85	7.56	6.84	9.36	0.61	—	—	—	—	—	—
G - 11	12.0	16.11	8.01	6.99	9.67	0.60	—	—	—	—	—	0.493
Soybean												
Bragg	9.78	—	—	—	6.77	0.85	41.80	0.680	1.180	—	0.456	0.403
Rapeseed/ mustara												
Varuna	12	—	—	—	2.09	0.98	—	0.572	—	—	—	—
Sunflower	12	11.57	5.57	3.57	6.13	0.45	—	0.422	—	—	—	0.40
Modern Safflower												
TSF – 1	7	8.93	4.67	4.33	5.65	0.63	—	0.588	—	—	—	—
Linseed												
LC - 54	5.20	4.64	2.30	1.20	2.34	0.50	35.44	0.732	1.134	—	—	—
LC - 185	10.60	4.61	2.23	1.03	2.20	0.48	35.85	0.712	1.110	—	—	—
Castor												
NPH - 1	7	9.98	6.85	5.07	7.02	0.70	—	0.568	—	6.60	—	0.47

fat supplly about 9.3 calories i. e. over twice that of proteins and carbohydrates. The oil also carry the essential fatty acids and fat soluble vitamins A, D and K required by the human body. The oil taken up by the body serve three purposes : (i) they are stored for future use as a reserve food in adipose tissues, the important depots being subcutaneous tissue, liver and intra muscular connective tissues (ii) the fatty acids combine with proteins in the formation of cellular protoplasm, cell membrane, etc., and (iii) the fatty acids are oxidised immediately to carbon dioxide and water. The energy, thus liberated is used to produce muscular work and maintain the body temperature.

The importance of poly-unsaturated fatty acids in the diet is now well recognised. They are reported to possess the property of lowering abnormally high cholestrol levels in blood vessels, and are recommended for patients with a high risk of coronory artery diseases. Safflower, sunflower and sesamum seed oils are rich sources of poly-unsaturated fatty acids. Modern nutritionists therefore, recommend a diet rich in vegetable oil in its natural form and low in animal fat while keeping the total calories intake constant. Table 2.3 presents the composition of oils produced by major oilseeds in India.

Table : 2.3 Composition of major oils

Types of oil	Saturated fatty acids, %					Unsaturated, %			Other, %	
	Myslic	Palmitic	Stearic	Arachidic	Above	Oleic	Linoleic	Linoleic	Erucic	Ricinolic
Groundnut	—	6-9	3-6	2.4	2-5	53.71	13–27	—	—	—
Rapeseed-mustard	—	1-3	0.4–3.5	0.5-2.4	1-3	12-24	12–16	7-10	40 55	—
Cottonseed	0.5-1.5	20-23	1–3	—	—	23-35	42-54	—	—	—
Soybean	—	7-11	2-6	0.3-3	—	15-33	43-56	5-11	—	—
Sesamum	—	7-9	4-5	—	—	48–49	35-47	—	—	—
Safflower	Traces	2–5	2-5	—	—	13–35	60–75	Traces	—	—
Niger	1.1-3.8	5.12	2.3–15 14 6	0.5-2.8	—	30–39	51-68	0-2	—	—
Linseed	—	4.7	2 5	0.3-1	—	12–34	17–24	35-60	—	—
Caster	—	—	0-1	—	—	Traces	4.5-5	—	—	85-95
Sunflower	—	3-6	1-3	0.5-1	—	14–43	44-75	—	—	—

3. POST HARVEST TECHNOLOGY OF OILSEEDS

Post harvest technology plays a key role in minimizing losses during handling, processing and preservation of oilseeds and their products. By adopting proper post harvest technology, the input cost in processing of oilseeds is reduced and oil yield is increased. Besides, several value added products can also be produced even at rural level by introduction of appropriate post harvest technology and thus the farmers can be motivated to grow more oilseeds.

The various post-harvest operations of oilseeds are described below.

3.1 Handling, Drying and Storage

Proper handling and storage of oilseeds is important for their processing into quality products since oilseeds are prone to auto-catalytic deteriorative processes, enzyme action, microbial spoilage, etc. Immature seeds, harvested before their enzymes have become dormant, deteriorate more rapidly than normal seeds during storage.

The moisture content of oilseeds at the time of harvest is usually high and uncongenial for their safe storage. Consequently all the oilseeds need to be dried prior to their storage. Sun drying is the traditional method used, however its limitations cannot be ruled out Mechanical drying of oilseeds at 105–110°C is preferable to minimize the quantitative and qualitative losses. The dried seeds also require adequate cleaning to remove sand, dirt, dust, leaves stems, weed seeds, stones, metal pieces and other extraneous matter before storing.

Immature seeds, high moisture seeds, dried seeds which become wet during storage, damaged seeds and sound seeds which suffer mechanical injury during handling and storage, respire at a faster rate. As a consequence, the oxygen uptake increases leading to the oxidation of polysaturated fatty acids and reduces the nutritive value and organoleptic quality of oils present in oilseeds. The faster rate of respiration also generates excessive heat that raises the temperature of seed mass and thereby accelerates its deterioration.

The most important factor in proper storage of oilseeds is their moisture content. Water in the seed is held by mechanical and/or chemical forces. The change of moisture content, as well as of all the other capillary porous colloidal matters, can be caused by the environment. In case of inadequate storage, the try glycerides may be decomposed, especially under the influence of ferments, micro-organisms as well as the chemical processes due to the increased temperature. In order to avoid these negative processes, the seed should be dried below the critical moisture-a point above which the ferments are activated and which depends on the oil content of seed The critical moisture contents for sunflower, groundnut, linseed and soybean are 8.5, 9.0, 10.5 and 13.0 percent respectively. Besides, a relative humidity of less than 65 per cent is also required for the safe storage of oilseeds. Higher moisture and relative humidity conditions favour the activity of lipolytic enzymes that increases the FFA content of oils under these conditions. The non-glyceride constituents of the seeds also degrade and produce oil soluble pigments which darken the colour of the oil, making it difficult to be bleached and render the colour of the oil unstable after bleaching. Some undesirable flavour changes in soybean and iodine conjugation in peanuts subjected to long storages have been reported. Besides ill-effects on oil quality, extensive deterioration of oilseeds during improper storage makes their mechanical processing difficult and leads to a low recovery even if no oil is actually destroyed. Degradative processes in high moisture oil seeds during adverse storage conditions of higher relative humidity and temperature increase the supply the nutrients for the growth of microflora. The microbial growth, if occurs, is accompanied by production of metabolites and mycotoxins, particularly aflatoxins.

Aflatoxins produced in oilseeds by strains of *Aspergilas flavus* come out partly in the expressed oil and the rest remain in the residual cake Such oil requires further refining for removal of its aflatoxin and render it unsafe for human consumption as such the deoiled meal, unless fully detoxified, is unsafe for even animal feeds.

Certain oilseeds like soybean require for some time storage to effect diminution in the chlorophyll content of green beans and obtain better yields of oil. Chlorophyll in the oil is undesirable because of the difficulty of removing green colour in subsequent processing and tendency of the colour to become intensified by hydrogenation. The yield of oil form newly harvested soybeans is less than that from the same beans stored for some period. Most oilseeds in India are packed in ordinary gunny bags for handling, transportation and storage. Storage is practised in heaps, stacks of bags, bins and cribs.

3.2 Grading

Grading of oilseeds is required to establish their general quality based on soundness, moisture content and freedom from impurities and also to evaluate their oil milling quality based on yield and quality of oil. The grade specifications of different oilseeds are based on (i) quantity of non-prime seeds including damaged, insect-infested seeds, slightly damaged seeds, shrivelled and immature seeds, (ii) type and quantity of impurities or foreign matter, (iii) moisture content of seeds, (iv) oil content, and (v) colour, acid value, iodine value and other indices of quality of extracted oil.

Although the considerations of oil content and its quality (acid value) in grading and valuation of oilseeds make the method more rational, it requires chemical analysis of all oilseed samples and hence it is not always practicable. Consequently, the standards that establish only the general quality of oilseeds are often used in India and that too in the organised trading of oilseeds. In unorganised trading the criteria of general quality of oilseeds are also often considered but on a qualitative basis rather than the quantitative basis.

3.3 Pre-treatments

There are three methods in vouge to accomplish oil extraction. Each of them is based on a different principle. The three methods are (i) emulsion method (ii) pressure extraction method and (iii) solvent extraction method. Irrespective of the method used, certain pre treatments of raw seeds are essential, if highest possible recovery of quality oil at an economical rate is to be obtained. Following pre-treatments improve oil yields and their quality.

3.3.1 Cleaning

Normally, the oilseeds are mixed with a variety of foreign materials viz. sand, stones, stalks, weed seeds, foilage, etc., during harvesting, handling and transportation. It is ideal to clean seed before putting it into store. Stone, iron and wood pieces mixed with seeds can disrupt mechanical equipment during processing. Foreign matters may lower protein content and increase fibre content of meal residue after extraction of the oil. Moreover, foreign matters mixed with oilseeds may be having high moisture content which may initiate overheating in storage. The local hot spots in the oilseed damage the quality and constitute a fire hazard if not properly detected and corrected by aeration or rotation. Also, cleaning before storage of oils not required further cleaning for processing and saves double handling of seeds. In short, proper cleaning of oilseeds can increase in crushing capacity of oil expelling units, reduce in-plant maintenance and improve the quality of oil and cake.

3.3.2 Dehulling (decortication)

The hulls of oilseeds are fibrous and have low oil content. Its proportion varies from oilseed to oilseed as shown in Table 3.1. Dehulling of oilseeds extraction is advantageous as the hulls, reduce the total oil yields and the capacity of extraction epuipment.

Table 3.1 : Approximate proportions of hulls and kernel in important oilseeds of India.

Oilseed	Kernel, %	Hull, %
Groundnut	75	25
Rapeseed mustard	80-82	18-20
Soybean	93	7

Sunflower	60–70	30-40
Safflower	50	50
Castor	70–80	20-30
Cottonseed	62	38
Sesamum	82–86	14-18
Linseed	57	43

3.3.3 Size reduction and flaking

The extraction of oil from oilseeds, either by mechanical expression or by means of solvents, is facilitated by reduction of the seed in small particles by grinding or rolling. Although a large proportion of oil bearing cells are disrupted, many oil cells remain intact even after the most careful size reduction and the walls of these cells are made permeable to the oil only by the action of heat and moisture in the subsequent cooking operation. However, the cell walls are more readily acted upon by heat and moisture if the seed particles are small. Hence the size reduction of oilsseds is important for efficient recovery of oils. Hammer mills/attrition mills are used for the preliminary reduction of size of large oilseeds while milling rolls are used for final reduction. The flake particle size of 0.13 - 0.25 mm obtained by rolling is satisfactory for hydraulic pressing of groundnut, cotton and linseed than irregular shape obtained by grinding. In the preparation of oilseed for expression in expellers or screw presses, the production of thin particles or flakes is not essential as heat is generated and seed particles are broken by shearing stress developed in the barrel of the expeller during oil expression. Small oilseed like sesamum, rapeseed/mustard and linseed as well as medium size oilseeds such as cottonseeds are usually rolled before expeller processing in large scale commercial plants. Soybeans. however are usually cracked by corrugated cracking rolls into particles averaging 10-16 merh in size and are then expressed without rolling or further reduction. Groundnuts are expelled after or before rolling.

Flaking is essential for preparing oilseeds for continuous solvent extraction since no other form of oilseed will facilitate oil extraction by disruptive effect of rolling as well as by reducing the distances so that solvent and oil must diffuse in and out of the seed during the reduction process. Since thin (0.20–0.25 mm) and coherent flakes of oilseeds like soybean or hydraulic/expeller pressed oilseed cakes are desired for solvent extraction, the flaking operation of the whole or cracked seeds or coarse grits of pressed cakes is carried out by flaking rolls in single passage.

About 10% moisture content of oilseed is registered for formation of thin and coherent flakes. In case of soybean, cracked beans are adjusted to a moisture content of 10 – 11%, heated and flaked while they are still hot and slightly plastic at a temperature of 72–75°C. In some cases the cracked beans are steamed for short period prior to flaking.

As far as ghanies are concerned, size reduction of seed is accomplished in the ghani itself. During this stage, the seeds are crushed and to some extent are powered. Friction, produced by the rubbing of seeds and pestle with each other against the background of pit wall, associated with pressure caused by the weight of pestle and the load exerted on it results in size reduction of seed. As the outer surface of the seed coat is generally smooth and slippery, some amount of water is also sprinkled to act as cementing material and to provide grip to the pestle.

3.3.4 Heat treatment

Almost all the oilseeds yield oil more readily if cooked adequatedly prior to their mechanical expression and/or solvent extraction. The cooking process coagulates the proteins present in the seed causing coalescence of oil droplets and making the seed permeable to the flow of oil. The process also decreases the affinity of oil for the solid surfaces of seed because of which the best possible yields of oil are obtained on expression/extraction of cooked seed. The cooking process also helps in imparting proper plasticity to seed mass. It insolibizes the phosphtides and related substances to reduce refining losses of oil. The cooking process destroys the moulds and bacteria to improve the micro-biological as well as keeping quality of oil cake.

Further the process destroys the heat labile anti-nutrictional factors to improve the nutritive value of protein rich oilseed meals. Heat supplements the work of water in cooking the meal and also in coagulating the albuminoids. On one hand, it weakens the cell walls by cooking and on the other causes volumetric expansion of the droplets which result in the rupture of cell walls and expulsion of oil. The cooking temperatures and its duration periods for durations of working for most oilseeds range between 105-130°C and 30-120 minutes respectively. Optimum conditions for cooking of an oilseed depend on several factors viz. initial moisture content, chemical and bio-chemical characteristics, cooking methods, equipment used, and method of oil extraction. Certain amount of moisture is essential in oilseeds (between 9-14.5%) to achieve the desirable heat effects on their cooking. Very dry oilseeds can not be efficiently heat treated without addition of some moisture. On the other hand, the oilseeds containing over 15% moisture require adequate drying during as well as after cooking to achieve efficient crushing. Optimal levels of moisture in most of the cooked oilseeds for hydraulic and expeller pressing is reported to be respectively 5-6 and2-3%.

Normal cooking of oilseeds has little effect on oil colour, rather it reduces impurities in oil and improves processing qulaity of oil and nutritive values of cakes. However, over cooking of oilseeds produces oil and cake of dark colour. Oil thus obtained is difficult to bleach and has low nutritive value.

The moisture content of cooked oilseeds is critically important in efficiency of their oil expresseion/extraction process. If the moisture content is more than the optimal, it results in slippage of the material in the expeller. If such oilseed is solvent extracted, the excessive moisture prevents the proper diffusion of the solvent into the oilseeds as well as creates non-percolation problems.

3.4 Recovery of Oil

Oil from oilseeds in India is mostly extracted with the help of traditional animal drawn ghanies (Kolhus), power ghanies, rotary oil mills, mechanical expellers and solvent extraction units. However, the solvent extraction techniques are also used for recovery of oil from soybean, rice bran and pressed oilseed cakes

3.4.1 The ghanies

The oilseeds processed in the ghanies are normally neither reduced in size nor cooked prior to their crushing. Heat is developed during crushing, The rise in temperature of seed mass is appreciably very low which provides an insufficent heat treatment to oilseeds. About 4% water is added in oilseeds for the hydration of proteins which helps in releasing oil during crushing. The oilseed cakes obtained from ghanies have a high percentage of oil (12-14%). These cakes are used in solvent extraction plant for further extraction of oil.

3.4.2 The expellers

Rotary mills, continuous expellers and screw presses are also used in India. The oilseeds are passed through expellers which exerts pressure in increasing order due to rotating screws or worms. Pressure and heat generated in expeller result the drainage of oil from oilseeds and the cake is ejected out of the barrel. The efficiency of oil expression depends on seed preparation. With a single pressing in an efficient expeller the cake obtained contains 6 $\pm$ 1% oil. Double pressing is followed in a rare case. Cake obtained after double pressing contains about 4% oil. Choice of double pressing depends on (i) the economics of the processes (ii) oilseed type and (iii) the end use of the cake. Excessive use of pressures to express more oil in single or double pressing also affects the quality of oil as well as the nutritional value of the oilseed cake and reduces the capacity of expellers. Now a days, the press solvent extraction technique is also being used where oil is first expelled at low pressure from oilseeds. The cake obtained contains more than 8% oil and is used in solvent extraction plant. This technique is advantageous as more oil is expelled using less energy. The quality of oil is good from nutritional and consumption point of views. Fig. 3.1 shows the flow diagram of mechanical oil expelling.

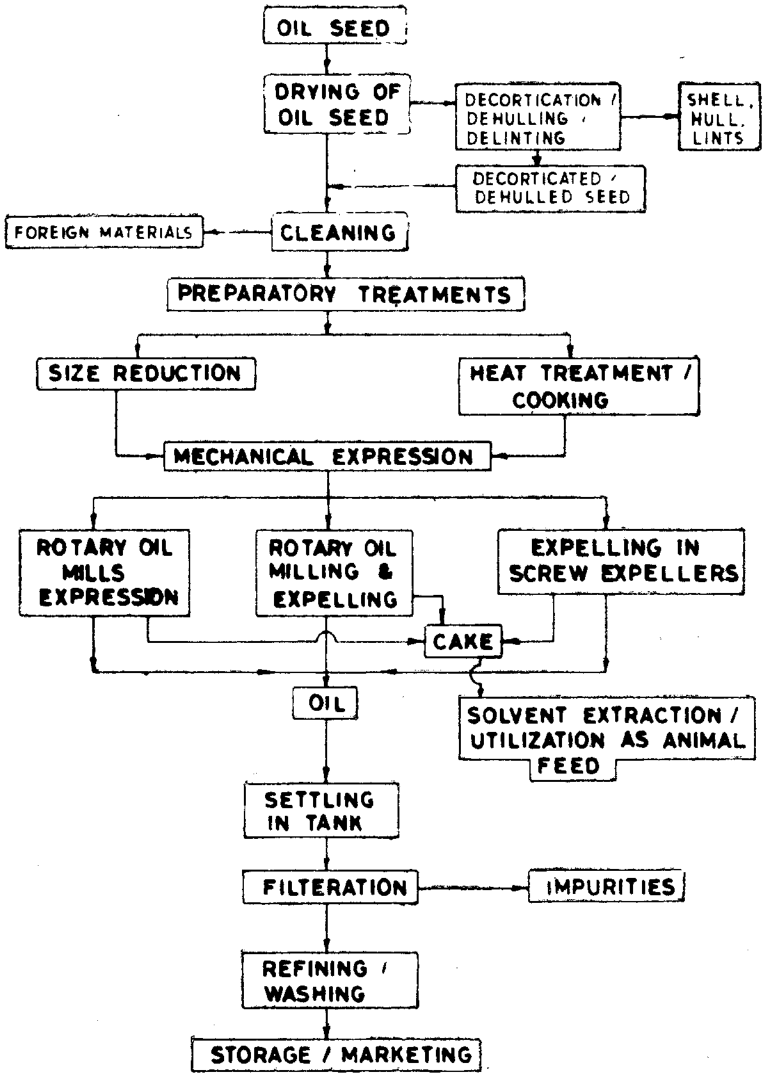


Fig. 3.1 Process Flow Chart of Mechanical Expression of Oil from Oil Seeds

Energy wise expellers are least energy consuming followed by improved and conventional ghanies. About 16 and 44% less energy is required respectively in case of improved ghanies and mechanical expellers as compared to conventional ghanies as shown in Table 3.2 (Singh & Bisht, 1983)

Table 3 2 : Energy requirement for oil expelling in different systems.

Description	Traditional ghani	Improved ghani	Oil expellers
Energy required/t of oil seeds, KWh	125	105	70
% energy requirement over traditional ghanies	100	84	56
Oilseed crushing per unit energy, kg/KWh	8	9.5	14
Increased amount of oilseed expelled per unit (KWh) energy over traditional ghanies, %	100	118.75	175

Source : Singh. H. P. and B. S. Bisht 1983.

3 4 3 Solvent extraction plants

Solvent extraction is the most efficient method of oil recovery from oil bearing materials. It is particularly advantageous for processing of those oilseeds/oil bearing materials which have low oil content viz; soybean, rice bran, mango kernels etc. The flakes of other oilseeds, e. g. groundnut, rapeseed/mustard, sunflower, linseed, etc. disintegrate in contact of solvent and create problems due to production of fine products. This problem is overcome by using pre-pressed cakes of these oilseeds for solvent extraction. Pre-pressing in expellers also recovers a major portion of oil from these seeds. However, pre-pressed cakes containing 12-20% oil require flaking prior to their solvent extraction for efficient recovery of oil. Solvent extraction plants are either batch or continuous types. However, the continuous counter current percolation systems are more popular in use because of its better efficiency.

Although a variety of solvents have been evaluated for extraction of oil from oilseeds viz; ethane, propane, carbon-dioxide, n-hexane etc., the most acceptable and widely used solvents are paraffinic potroleum fractions of hexane type neptha with a boiling temperature range of 64-70°C. Food grade n-hexane is used for extraction if the residual oilseeds cake is to be utilized for edible purposes.

The thickness of the flakes and the residual oil content of the material are the two important factors that affect the rate of oil extraction. If the flake thickness is increased three times, the rate of oil extraction decreases by eighty times. Fig. 3.2 shows the process flow chart of solvent extraction of oil in a plant.

3.5 Refining and Vanaspati Production

Normally the crude oil obtained from mills is passed through a filter press at high speed so that sediment free oil is obtained. In case of ghani oil, most of the sediments are allowed to settle gradually by keeping the oil for 24 hours The oil is filtered once the sediments are setteled. However, for refining of solvent extracted oil and for production of Vanaspati, several other unit operations viz; degumming, neutralization of fatty acids, blanching, deodorization, hydrogenation etc., as shown in Fig. 3.3 are practiced.

3.6 Packaging of Oil

The crude as well as refined oils are packed in glass, metal or plastic containers for marketing.

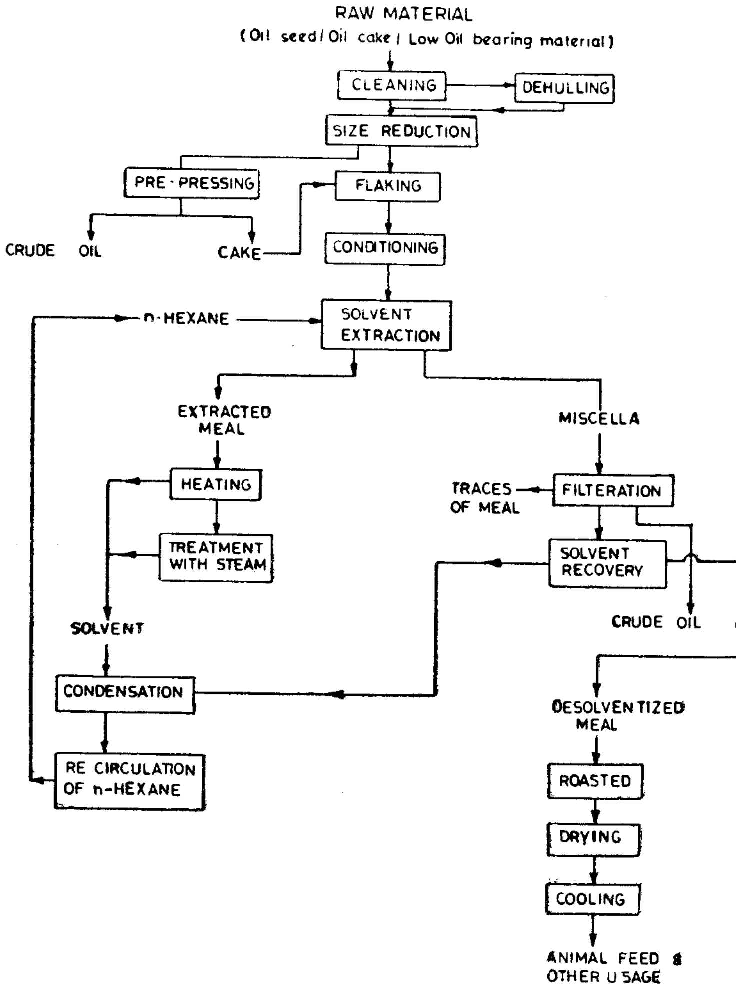


Fig. 3.2 Process Flow Chart of Solvent Extraction of Oil

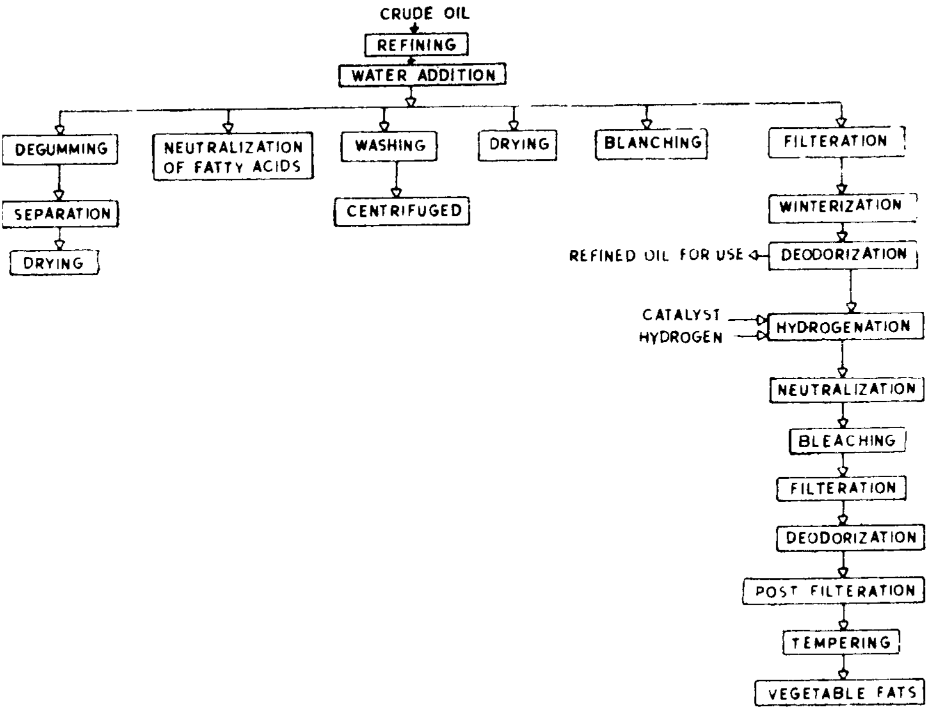


Fig. 3.3 Flow Chart for Refining and Production of Vanaspati from Crude Vegetable Oils

3.7 Utilization of Deoiled Cake/Meal

The ghani/expeller pressed cakes contain high amount of oil which goes waste if the cake is as such used for cattle feed. Therefore,these cakes are further solvent extracted as discussed earlier.

The oil content of the cakes affect their storage quality because of its susceptibitity to oxidative deterioration. The FFA content of residual oil in ghani and expeller pressed cakes increases during storage if the moisture content of the cakes is high. The nutritional quality of oil-seed cakes depends on its content like protein, crude fibre, acid insoluble ash and other anti-nutritional factor. The cake quality is also governed by the processing and expelling conditions of the oilseeds.

The deoiled meals/cakes. however, is mostly used either as animal poultry feed or manure. Table 3.3 shows the metabolizable energy contents of some oilseed meals (Zombade and Ichhponani, 1984).

Table 3.3 : Metabolizable energy content ot some oilseed meals used as animal/poultry feed

Oilseed meal/material	Metabolizable energy, kcal/kg
Soybean cake	2520
Mustard cake	2332
Groundnut cake	2750
Til cake	2400
Sunflower cake	2110
Cotton seed cake	1534
Sal seed meal	1700
Rice bran meal/cake	2015
Coconut cake	1190

The manurial value of oil cakes lies mainly in its nitrogen content which varies from 3 to well over 9% depending upon the type of oil cake, its oil content and hull/husk present in it. Seeds dehulled/decocticated before extraction gives a product which is richer in nitrogen than those which are not dehulled or decorticated. C/N ratio of oil cakes is usually narrow, being 3 to 15 for most of oil cakes. Nearly 50-80% of nitrogen is mineralized within 2-3 months time.

Oil cake production in India is estimated to be about 8. 9 million tonnes in 1989-90 based on oil recovery ratios applied to major oilseeds available for crushing (SEA Hand book, 1990). Considering 2.26 million tonnes of oil cake being exported and 4.33 million tonnes of oil cake processed by solvent extraction plants, it may be estimated that about 2 31 million tonnes of oil cake is fed to cattle. Assuming the average oil content of this cake, mainly coming from ghanies and other low pressure systerns, to be as low as 15%, it is estimated that about 0.35 million tonnes of oil is lost through oil cake fed to cettle.

3.8 Marketing of Oilseeds

Major portion of the various oilseeds produced in India is utilized for production of oil and cake. For processing of oilseeds the growers sell their oilseed produce to oil millers through various agencies which include financial intermediaries, government agencies, ratailers, whole salers etc. The oil seeds market include (i) local markets at rural level where in small procersors, mostly ghani owners, purchase oii seeds, (ii) urban markets, normally governed by large scale processors and (iii) the gover nment regulated markets. In absence of any simple technology, the quality of oilseeds is judged by texture, look and taste The quality factors viz. oil content, FFA content, moisture content etc. are not used for deciding the quality of oilseeds.

4. GROUNDNUT

Groundnut is a major oilseed of India. Out of about 17.8 million tonnes of oilseeds produced in 1988-89, groundnut accounted for 9.5 million tonnes. It yields 70% kernel and 28% oil (pod basis). This chapter describes various types of strippers, grader, driers, decorticators and oil expelling units designed and developed in India for carrying out various processing operations of this important oilseed. The chapter also describes the drying and storage technology as well as method for control of Aflatoxin in groundnut.

4.1 Stripping

The process of removing groundnut pod from the plants or haulms is known as stripping. The most common method of stripping is to pull out the pods from the plants manually, yielding 9 kg pods per hour with a stripping efficiency of 91%. TNAU, Coimbatore has developed two types of manually operated strippers namely; comb type and drum type. (Fig 4.1 and 4.2). In addition, TNAU, Coimbatore and

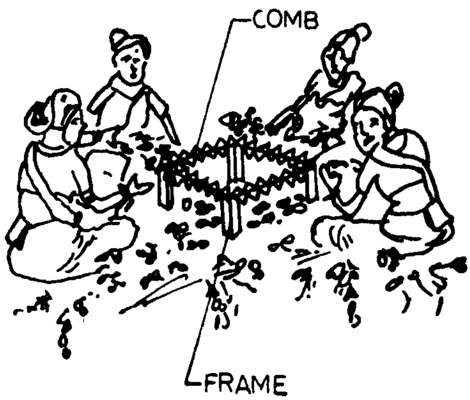


Fig. 4 1 Groundnut Stripper (Comb type)

UAS, Raichur have also developed power operated groundnut strippers as shown in the Figures 4.3 and 4.4. Table 4.1 presents the specifications and test results of these strippers.

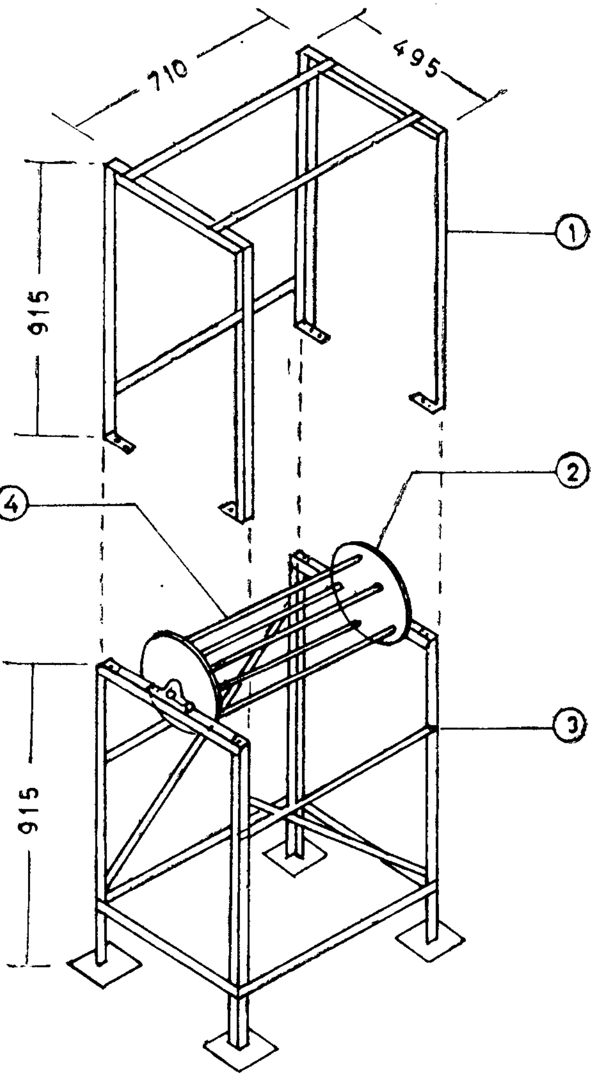


Fig. 4.2 Groundnut Stripper (Drum type)

1. Hood Frame 2. Revolving Drum 3. Frame
4. Hollow Rubber Tubes (M S. Rod Inside)
Dimensions in mm

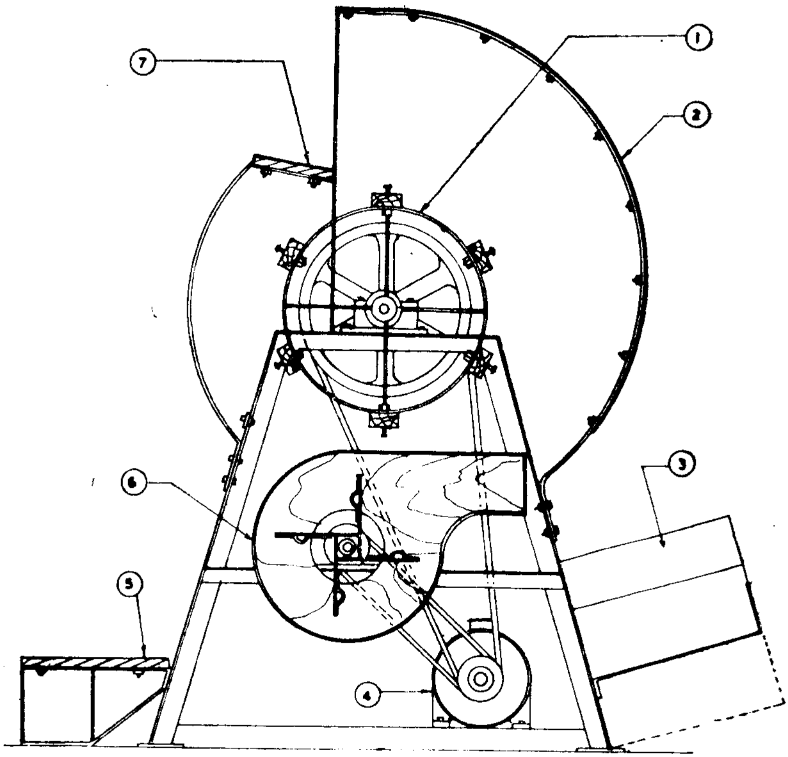


Fig. 4.3 TNAU Model Power Operated Groundnut Stripper

1. Stripping Drum 2. Hood 3. Collecting Tray 4. Motor 5. Platform 6. Blower 7. Feeding Plank

4.2 Grading

A power operated groundnut grader has been developed at TNAU, Coimbatore. Fig. 4.5 shows this grader which has the following specifications :

Type	:	Slotted oscillating sieve
Capacity, kg/h	:	600
Power requirement	:	1 hp electric motor
Labour requirement	:	Two
Cost of equipment, Rs	:	5,000/=
Cost of operation, Rs/t	:	24

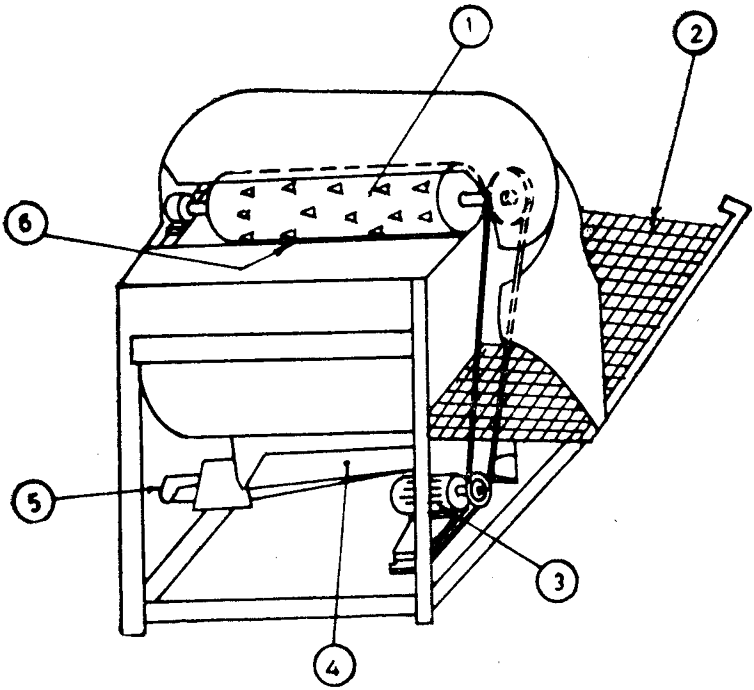


Fig. 4.4 Power Operated Groundnut Stripper (UAS Model)

1. Separating Drum 2. Cleaning Mesh 3. Motor 4. Blower 5. Collecting Chute 6. Feeding Trough

Table : 4.1 Comparative study of groundnut strippers

Specifications/ Test results	Manual strippers TNAU models		Power operated strippers TNAU model	UAS model
Type	Drum	Comb	Rotor	Loop
Capacity, kg/h	16.5	10.75	100.0	70.0
Power requirement, hp	Manual	Manual	1.5	3.0
Labour requirement	1	4	4	2
Stripping efficiency, %	98 0	99.0	93.0	90.0
Breakage, %	0.7	1.5	—	—
Cost of equipment, Rs	300	150	8000	6000

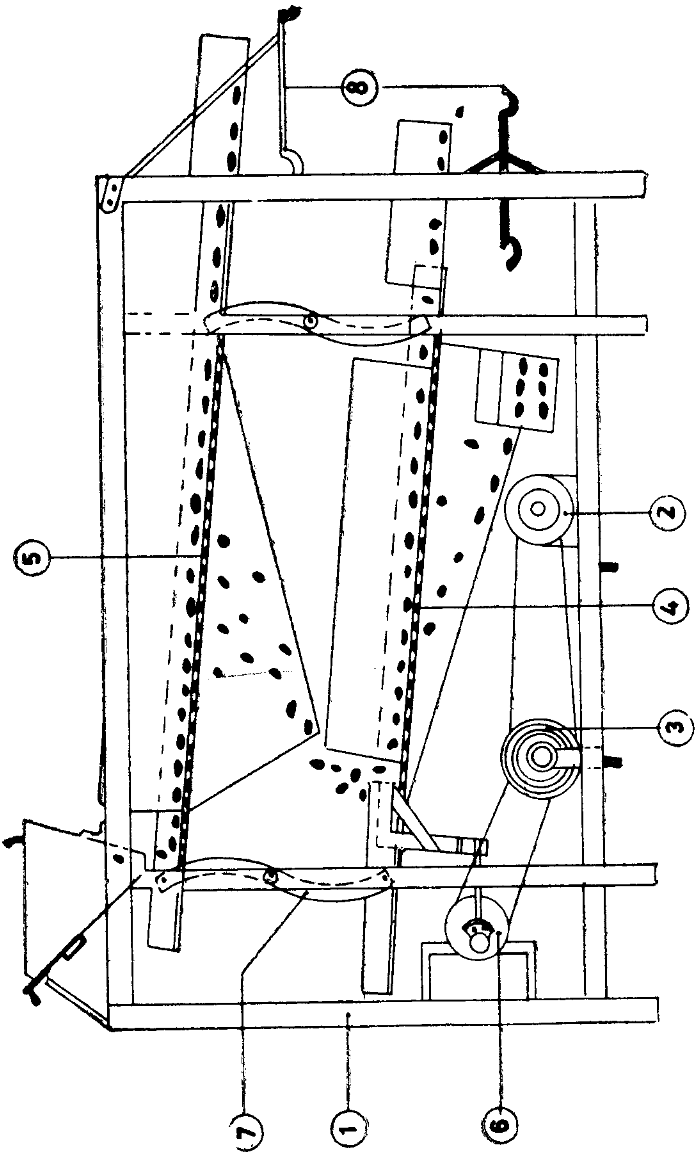


Fig. 4.5 Grounddut Grader

1. Frame 2 Motor 3. Stopped Cone Pulley 4. Bottom Sieve
5. Top Sieve 6. Eccentric 7. Bell Crank Lever 8. Gunny Bag Holder

4.3 Drying

During drying of groundnut, moisture passes quickly from kernels to pods and since the process continues after drying has ceased, overdrying of pods must be avoided. Over heated kernels are extremely brittle, can change colour and lose their flavour, all of which reduces their value. Slow drying is preferable to fast in terms of final quality.

In majority of groundnut producing countries, the drying process is simple and most often consists of standing the filled sacks, top open, untill the pods are dry enough to be shelled, stacked or transported. In case of mechanical driers, portable trailor bins, radial drying bins and vertical flow bins are all suitable for unshelled groundnuts. Continuous flow dryers are normally suitable for larger producers or cooperatives.

In India, groundnut is traditionally dried in sun which requires 4-6 days for reducing the moisture content of groundnut pods from 26% to 13% on mud floor. On cement floor, the drying takes place faster and reduces about 1/3 of total drying time in comparison to earthen floor (IIT, Kharagpur). As per studies conducted at TNAU, Coimbatare, about 15 h are required to reduce the moisture content from 29% to 9% in mechanical drier at an airflow rate of 27 cfm and bed thickness of 15 cm for POL-2 variety pods at 35°C temperature. In case of TMV–7 variety, 21 h are required to reduce the moisture from 29.8 to 7.3%. For such reduction in moisture content, sundrying requires 48 to 72 h. Though drying methods do not effect the viability of seed, however, it is reported that about 1% oil cntent is reduced when groundnut is dried by a mechanical drier compared to shade dried seeds.

For mechanical drying of groundnut, 3 driers have been designed, developed and tested. The specifications and test results of these driers are given in Table 4.2 while Figures 4 6 to 4.8 show these driers.

PKV, Akola has developed a waste fired drier which is fabricated with locally available materials. The drier (Fig. 4.9) costs about Rs. 10,000/ and can dry about 3·5 t pods/d. The best drying temperature for groundnut is 36–58°C.

GAU, Junagadh has developed a plastic enclosure (Fig. 4.10) with a floor area of 6 m × 4 m and 2 m height for sundrying of groundnut. Tnis structure needs 8–9 days to reduce the moisture

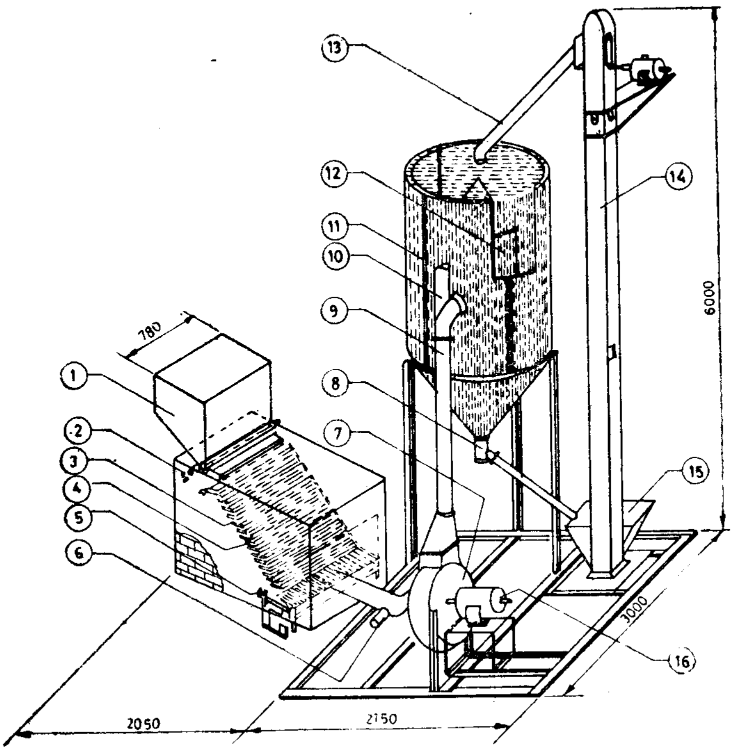


Fig. 4.6 Recitculating Bath Drier

1. Hopper 2. Pulley 3. Inclined Grate 4. Furnace Space
5. Rotating Lever 6. Secondary Inlet 7. Blower 8. Discharge Gate
9. Hot Air Duct 10. Flue Gas Exit By Pass 11. Outer Cylinder
12. Inner Cylinder 13. Delivery Pipe 14. Bucket Elevator
15. Seed Loading/Discharge Hopper 16. Motor

All Dimensions are in mm

content of pods from 43.5 to 18% (wb). Under this enclosure, the pods are protected from the unfavourable weather conditions, animals, birds and insects. However, this structure, when not in use for drying purpose, could also be conveniently used for storage or as a green house. GAU, Junagadh has also developed a flat plate solar collector type batch dryer (capacity 200 kg/batch) with floor size of 4 m ×

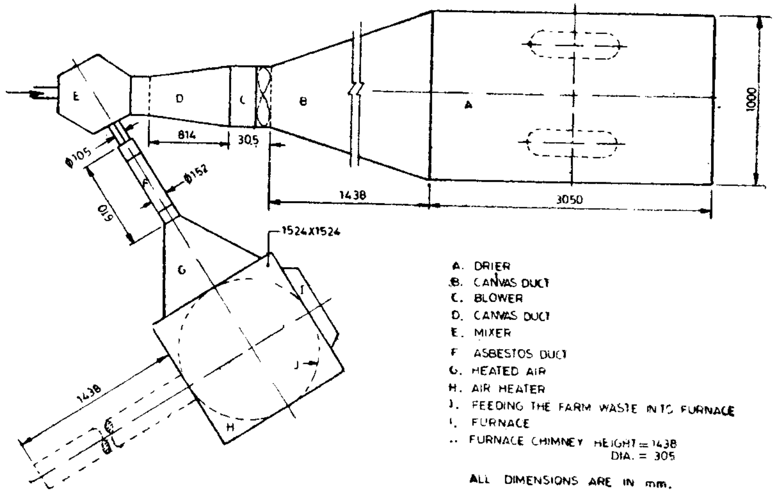


Fig. 4.7 Portable Batch Drier

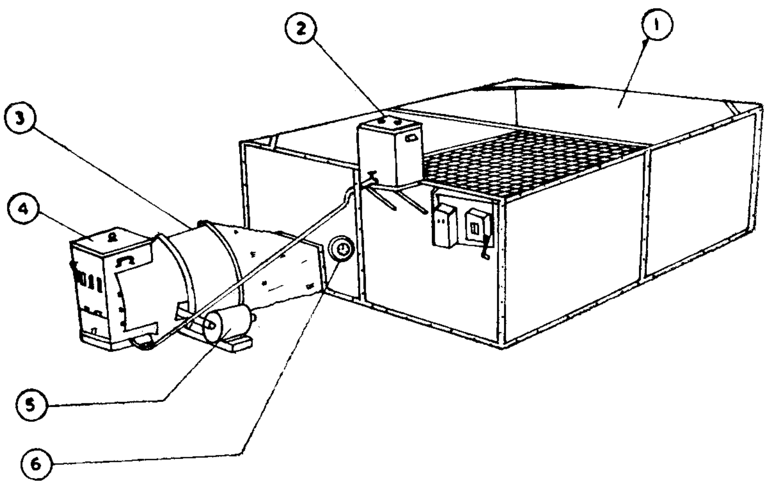


Fig. 4.8 Bin Drier

1. Drying Chamber 2. Fuel Tank 3. Blower 4. Burner
5. Motor 6. Thermometer

2.5 m for freshly harvested groundnut vines and pods (Fig. 4.11). It is reported that the duration for drying of freshly harvested whole groundnut plants form 65% to 15% m.c. is reduced by half (2 d) using solar dryer by supplying ambient air as compared to the traditional method.

Table : 4.2 Comparative study of groundnut driers

Specifications/ test results	Driers		
	Recirculating batch drier	Portable batch drier	Bin drier
Developed at	I.I.T. Kharagpur	P.AU. Ludhiana	T.N.A.U. Coimbatore
Capacity	1250 kg/batch (Shelled groundnut)	—	80 kg/h
Power requirement, hp	5	5	2
Labour requirement	2	2	1
Cost of drier, Rs	40,000	5,000	9,500
Suitability for other crops	Paddy, wheat, maize, sorghum, millets. pulses etc.	rice, wheat, maize etc.	paddy, millets

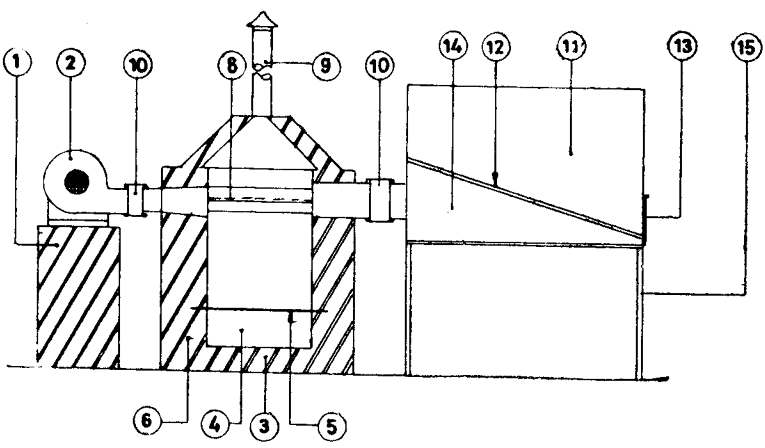
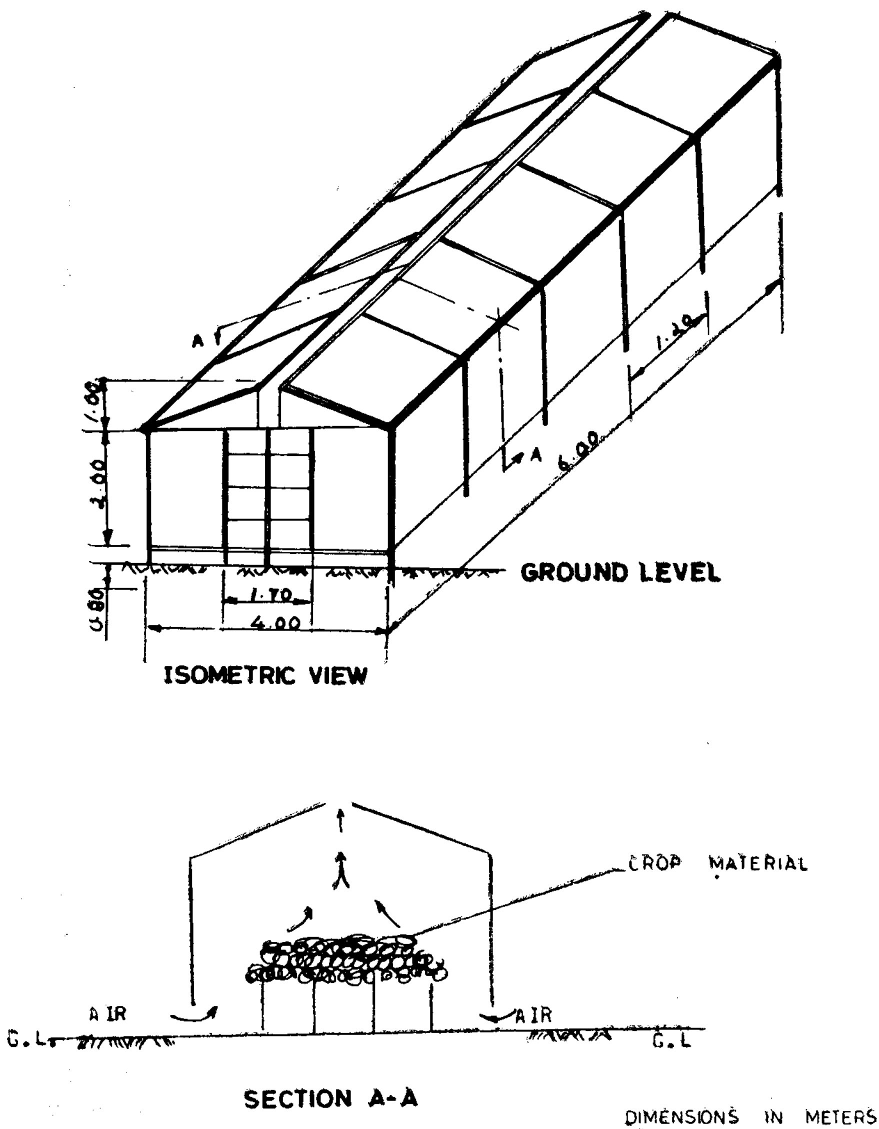


Fig. 4.9 Section of Waste Fired Dryer

1. Blower 2. Foundation for Blower 3. Foundation for Furnance 4. Ash Collection 5. Grate 6. Brick Wall 23 cm. Thick 7. Furnace 60 Cm. × 60 Cm. 8. Heat Exchanger 9. Cnimney 10. Canvas Duct 11. Dry Bin 12. False Bottom 13. Grain Outlet 14. Planum Chamber 15. Stand



Fig, 4.10 Details of the Plastic Enclosure Construction for Groundnut Solar Drying

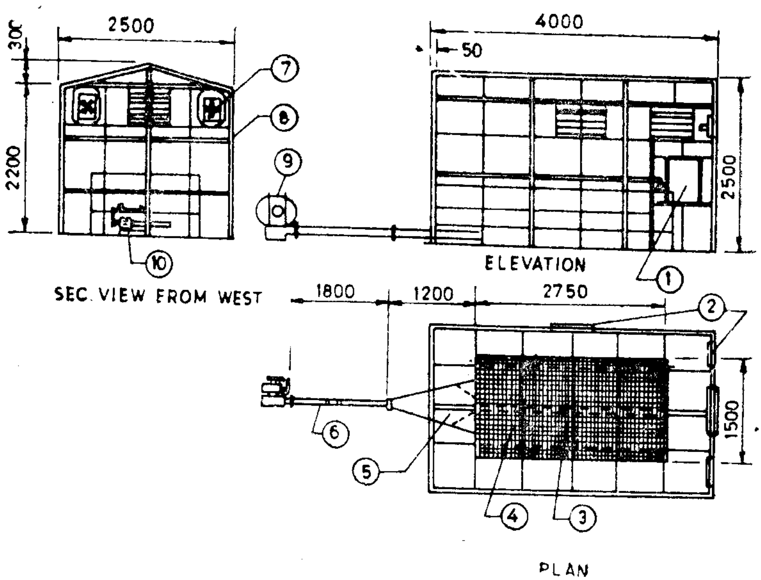


Fig. 4.11 Solar Dryer-Cum-Green House

1. Enterance Door 2. Ventilators 3. Plenum Chamber 4. Wire Mesh (4G × 400 mm) 5. Trapezoidal Extension 6. Pilot Tube 7. Exhaust Fan 8. Main Frame 9. Air Blower 10. Blower Motor

All Dimensions in mm

4.4 Decortication

Traditionally groundnut pods are decorticated by hand shelling for removal and separation of the kernels. By this method, the output per man hour is very low (1-2.5kg/h). which results in very high unit cost of shelling. Several types of decorticators have been developed in the country but among them. the CIAE manually operated (Fig. 4.12) and TNAU decorticators (Fig. 4.13 to 4.14) have been found most suitable. Table 4.3 presents a comparative study of these decorticators.

CIAE, Bhopal has modified its decorticator giving two new prototypes viz. (i) a mini decorticator useful for rural women who are usually accostomed to work in sitting posture and (ii) decorticator with

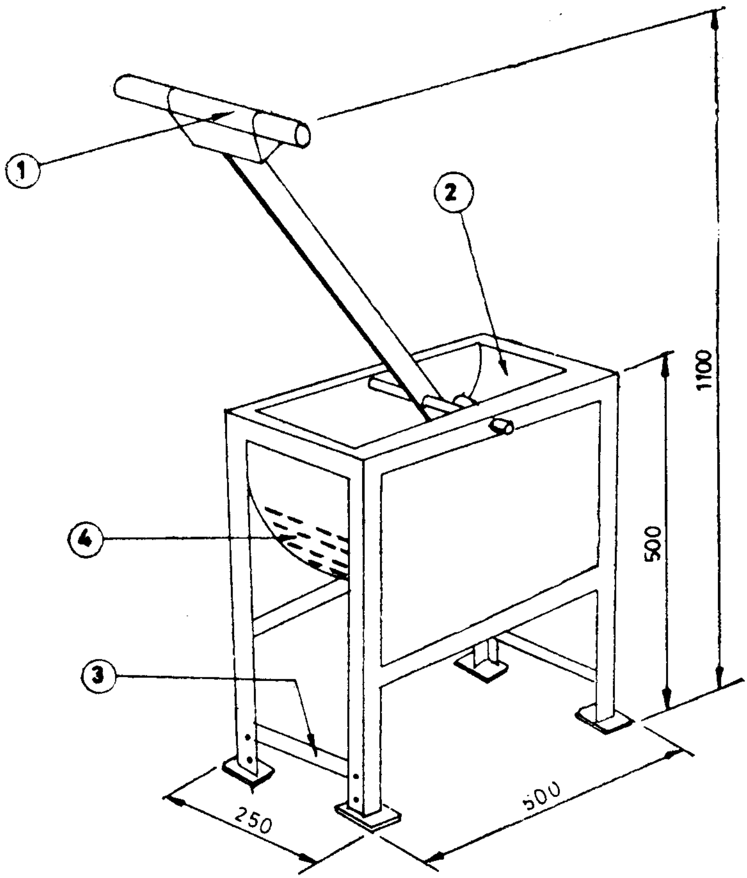


Fig. 4.12 Manual Groundnut Decorticator (CIAE Model)

1. Handle 2. Hopper 3. Foot Rest 4. Sieve

feeder-cum-separator attachment. The mini decorticator is small in size (250 mm × 500 mm × 630mm), light in weight (5.7 kg) and low in cost (Rs 175/-). Its capacity is about 35-40 kg pods/h with 1-2% brokens. There is no adverse effect on germination of seeds by use of this equipment. The other prototype (Fig. 4.15) provided with a feeder and separator attachment has a sieve of 250 mm × 500 mm size (dia of holes 11 mm). The feeder is reported to facilitate the easy operation of the equipment with an increased capacity of 50-55

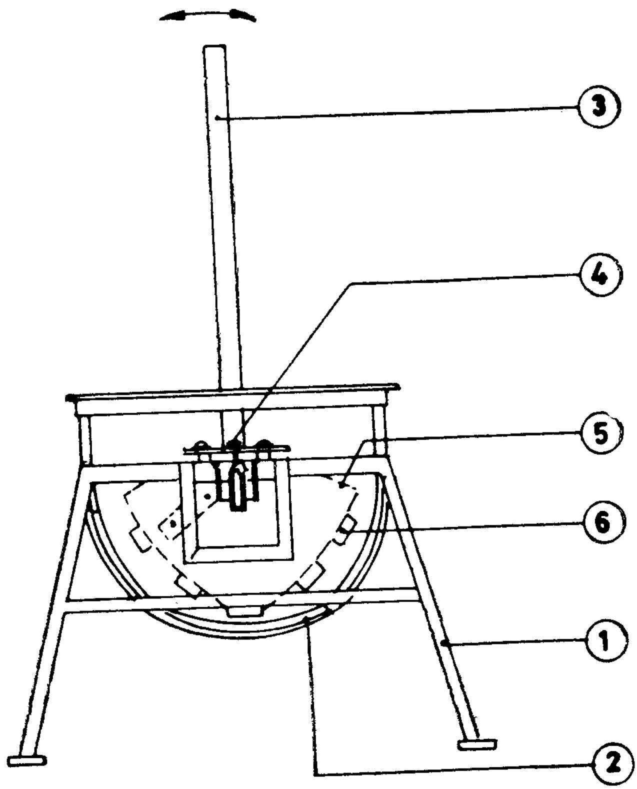


Fig. 4.13 Improved Hand Operated Groundnut Decorticator

1. Stand 2. Sieve 3. Handle 4. Clearance Adjusting Bolt
5. Occillating Sector 6. Pegs

kg pods/h, (25-37% more than the previous design). Damage to the kernels reduced from 2 to 1% giving 70-75% separation efficiency and 100% shelling efficiency.

Rubber tire has been reported useful in design of groundnut shellers in Thailand. Basad on the experience of Thailand, a motorised rubber tire grounnnut sheller has been developed at CIAE Bhopal Fig. 4.16). This sheller is operated by a 2 HP electric motor. A three layer sieve has been provided for grading of kernels. The speed of grading sieve is 250 rpm with 50 mm stroke.

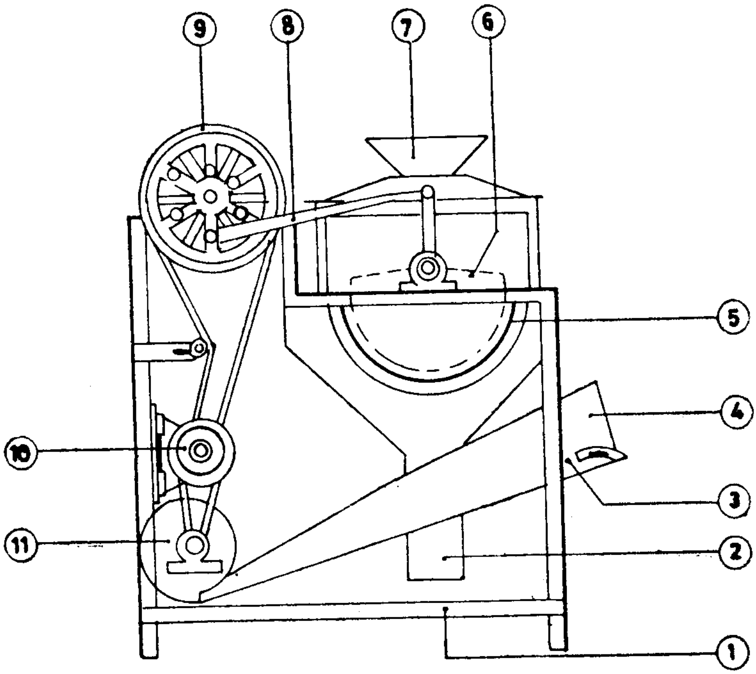


Fig. 4.14 Power Operated TNAU Model Groundnut
1. Frame 2. Kernel 3. Chute 4. Hull 5. Concave Sieve
6. Occillating Rod 7. Feed Hopper 8 Connecting Rod
9. Fly Wheel 10. Electric Motor 11. Blower

Table : 4.3 Comparative study of groundnut decorticators

Specifications/ Test results	Manually operated decorticators		Power operated decorticator
	CIAE Model	TNAU Model	TNAU Model
Type	Peg and batch	Oscillating sector	Oscillating drum concave
Capacity, kg/h	45-60 (pods)	12 (kernels)	260 (kernels)
Shelling efficiency, %	99.0	98.0	95.8
power requirement,	Manual	Manual	5 hp
Labour requirement	Two	One	Two
Cost of equipment, Rs.	250	750	4,700
Cost of decortication Rs/t	152.0	43.20	40

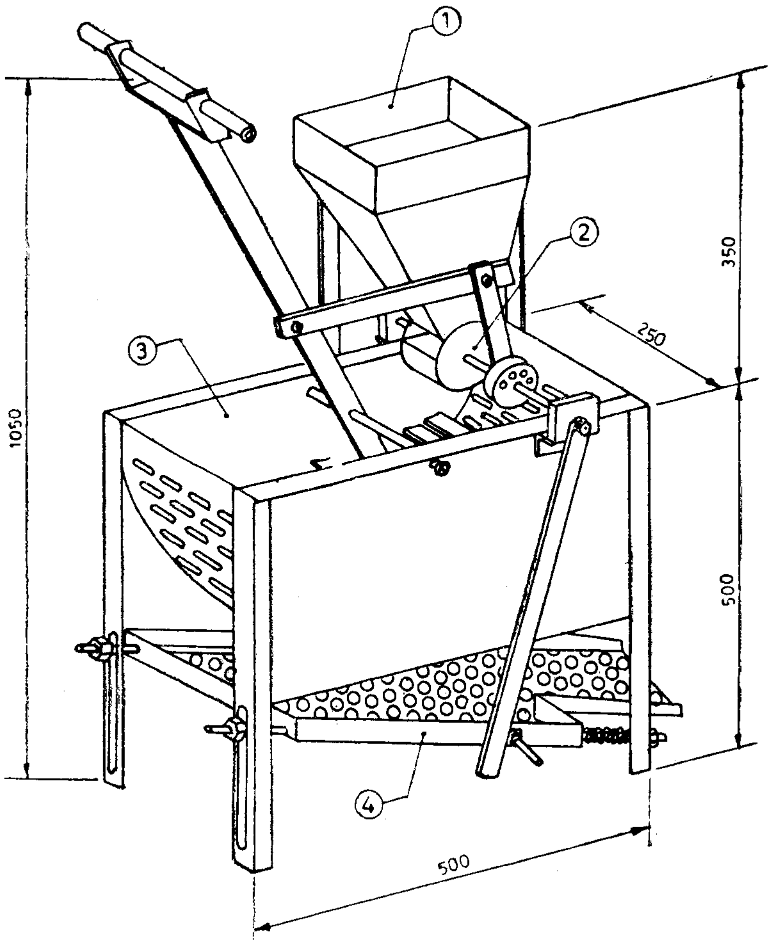


Fig. 4.15 CIAE Groundnut Decorticator Attached with Feeder & Separator

1. Hopper 2. Feeder 3. Decorticating Unit 4. Separator

In addition to above mentioned decorticators, a manually-cum-power opetated groundnut decorticator has also been devoloped at J. N. T U., Anandpur. With one HP electric motor, the unit (Fig. 4.17) can decorticate about 150 kg pods/h with 94–96% decortication efficiency. It is claimed that no breakage takes place and 57–63% sound kernels are obtained which could be used as seed. The cost

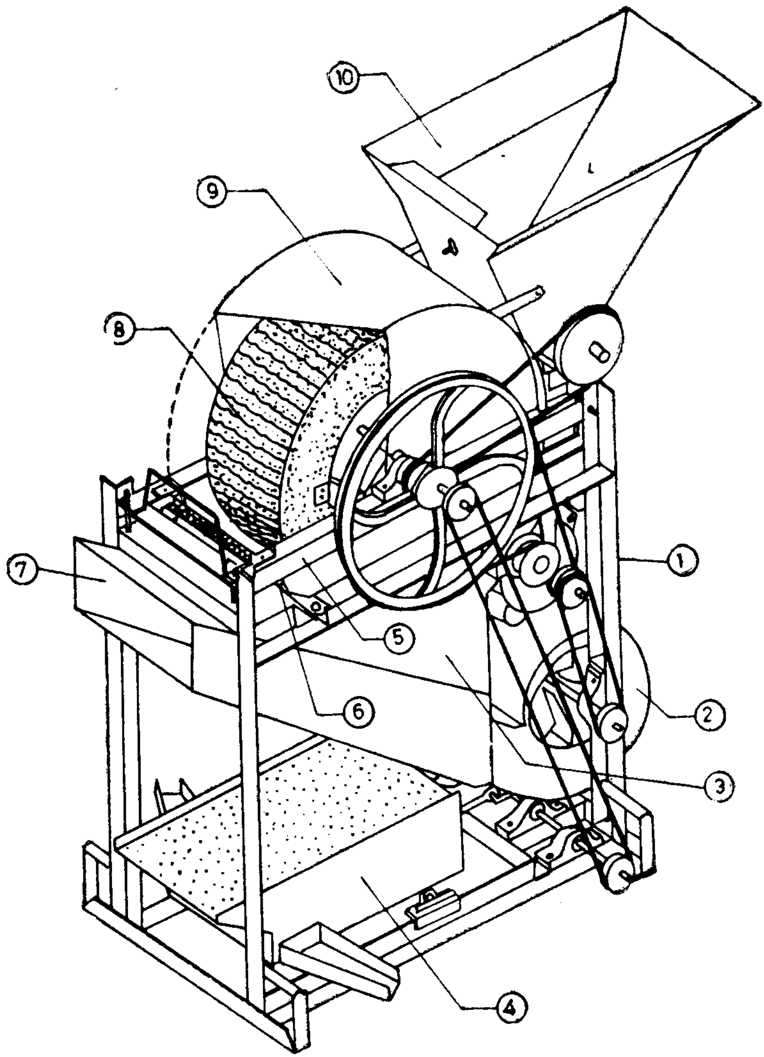


Fig. 4.16 Motorized Rubber Tire–Sheller

1. Main Frame 2. Blower 3. Trough 4. Grading
5. Rubber Tire Frame 6. Concave 7. Blower Chute
Rubber Tire Assombly 9. Cover 10. Feed Hopper

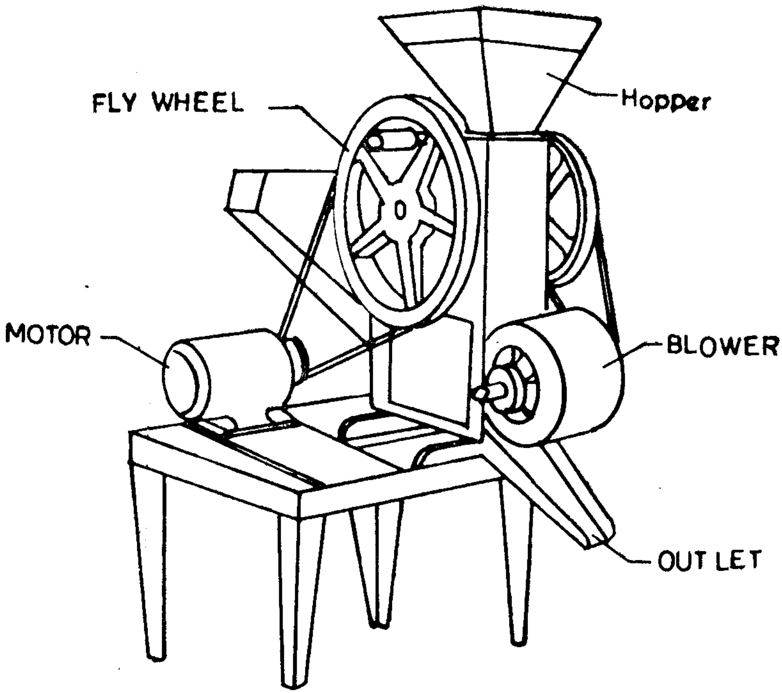


Fig. 4.17 Power Operated Mini Groundnut Decorticator

Rs 3000/- (exculuding motor) and the cost of decortication works out about to be Rs. 40/t of pods.

4.5 Storage of Pod/Kernels

Unshelled groundnuts are normally stored in bags or bulk. However, care is to be taken so as to not store them in direct sunlight otherwise they would become very dark and suffer high damage during decortication. Decorticated nuts store well, if dry but are very susceptible to insect and vitamin damage. High temperature adversely effects the oil quality and viability. Sound, unbroken and undecorficated groundnuts are less susceptible to insect attacks in storage than shelled nuts but if the testa of the latter is unbroken they are also resistant to damage. For storage of shelled seed and breeding stock, of deeorticator is an air conditioned store is almost essential if nuts are to retain their viability for more than a season. A temperature of 2–4°C with a Rh of 6 5% allows storage for atleast 2 years with little loss of viability. For less critical uses, low oxygen or nitrogen atmospheres can improve shelled groundnut storage.

In Indian conditions, small amounts of shelled dried seed, treated with some insecticide could be successfully stored for one year without significant loss of viability in laminated polylinyl bags. (Ramamoorthy, 1979). Studies conducted at P K V., Akola (1974) showed that out of various storage structures used for groundnut, polyethylene bags were found most suitable recording minimum storage loss of only 5.8% as compared to 8 7% in PKV bin, 9% in gunny bags/rectangular metal bins, 9.3% in mud plastered Nirgudi (local) bins and 10 7% in Pusa and Hapur bins. The insect species recorded were *Coeyra Cephalonica Staint* and *Tribolium Castaneum*. Oil content of pods decreased slightly during storage.

To reduce the space requirements and labour involved in storage of groundnut pods, the storage of shelled groundnut was studied at UAS, Raichur (1977). Six types of different storage structures, namely; plywood, metal, plastic, earthen pots, gunny bags and polyethylene bags were evaluated for this purpose. The physical condition of groundnut kernels in plywood and metal bins after 09 months was quite unsatisfactory. Considering various parameters viz; seed damage, germination percentage and protein content, higher ratings were given to earthen pots and polyethylene bags as shown in Table 4.4.

The safe moisture content limit for storage of groundnut kernels and pods are 4–6% and 7–9% respectively. However, studies conducted at TNAU, Coimbatore (1978) showed that groundnut variety SBX–1 could be safely stored for 9 months at a moisture level of 9-10%. Due to efficiency of the improved storage structures, the free fatty acid's formation, which is an indication of seed quality deterioration was minimum in the plywood storage bin as compared to other structures as shown in Table 4.5.

Table 4 4 : Comparative performance of various storage structures for groudnut kernels

Storage Structure	Fat acidity mg/koH, %	Oil content, %	Protein content % (oil free basis)	Seed damage %	Germination, %
Fresh sample values	15	48.11	52.76	—	—
Plywood	57.75	46.57	52.69	17.31	31.00
Metal	64.00	41.44	49.88	33.09	7.16
Plastic	61.68	45.88	50.07	15.82	11.50
Earthen pots	45.25	46.72	51.35	6.79	59.00
Gunny bags	54.41	46.16	50.74	9.17	35.83
Polyethylene bags	46.71	47.77	50.49	4.40	44.83

A similar study has been conducted at IIT, Kharagpur where groundnut pods of TMV-2 variety (m. c. 5.8%) were stored in 4 types of storage structures for 120 days. These structures were earthen pot, tar painted polyethylene lined bamboo bin (TPB), bamboo cement bin and metal bin. Moisture content of groundnut increased with storage time for each type of storage structure, however, the degree of rise in moisture was highest for seeds kept in tar painted polyethylene lined bamboo bin and least in metal bin (Fig 4.18). As the seeds became aged, there was a continuous loss in dry weight of groundnut in all structures. This loss in weight was maximum in tar-painted polyethylene lined bamboo bin and minimum in metal bin (Fig. 4.19). Fig. 4.20 shows the influence of storage period on germination and root/shoot lengths which decreased with increase in storage time. However, metal bin was found to be the best structure and TP bin as worst structure in terms of germination. Appreciable changes were observed in shoot length of groundnut as shown in Fig. 4.21. The variations in electrical conductance, iodine number, saponification value, total oil content and free fatty acid content after 120 days are

Table 4.5 : Evaluation of different storage structures for groundnut pods

Particulars	Hapur bin	Plastic silo	Ply-wood bin	Double walled PE lined bamboo bin	Coal tar drum bin	Gunny bags
Cost, Rs.	350	125	200	100	60	25 (for 5 Nos.)
Capacity, kg	300	300	300	300	80	150 (for 5 Nos.)
Moisture content % (wb)						
initial	10.0	10.0	10.0	10.0	10.0	10.0
final	10.2	10.7	10.4	10.8	10.2	10.8
Grain temp. °C						
initial	31	31	31	31	31	31
final	31.2	31.2	30.4	30.5	31.2	31.0
Loss in weihght due to insect infestation, %						
initial	Nil	Nil	Nil	Nil	Nil	Nil
final	14.73	14.27	8.8	12.51	12.51	22.32
Germination, %						
initial	76.0	76.0	76.0	76.0	76.0	76.0
final	70.0	72.0	72.0	68.0	70.0	64.0
Biochemical changes						
a) Proteins, %						
initial	24.66	24.66	24.66	24.66	24.66	24.66
final	24.70	24.37	24.25	24.60	24.20	24.75
b) Carbohydrate, %						
initial	15.18	15.18	15.18	15.18	15.18	15.18
final	15.25	15.29	15.59	15.55	15.40	15.75
c) FFA, % mg of KOH/g						
initial	1.03	1.03	1.03	1.03	1.03	1.03
final	3.36	2.25	2.22	1.99	2.59	1.95
d) Oil Content, %						
initial	49.15	49.15	49.15	49.15	49.15	49.15
final	48.80	48.25	49.95	49.0	48.90	48.95

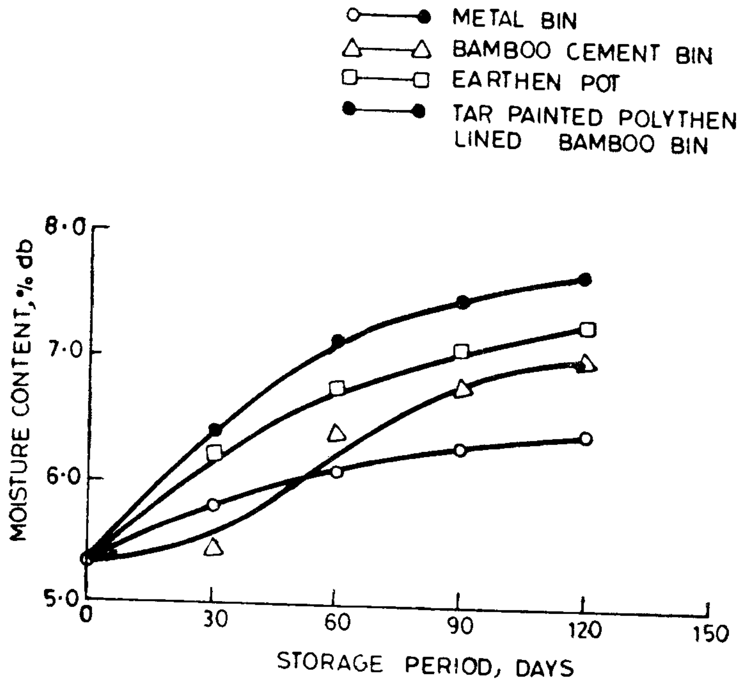


Fig. 4.18 Moisture Content of Groundnut (Kernel) Stored in Different Storage Structure

shown in Tables 4.6 and 4.7, Development of free fatty acidity, presented in Fig. 4.22 showed that both metal bin and bamboo-Cement bin could resist the formation of appreciable amount of FFA upto 90 days. On the other hand FFA rose very sharply between 30 to 60 days of storage and then decreased again sharply to a very lower value during 60 to 120 days in earthen pot and tar-painted PE lined bamboo bin. This indicates that groundnut deteoriates very fast in these two structures after 60 days of storage. From the insect infestation point of view, tar painted PE bamboo bin was observed to be the worst as shown in Table 4.8 (Annual Report, IIT, Kharagpur Centre of PHTS, 1983).

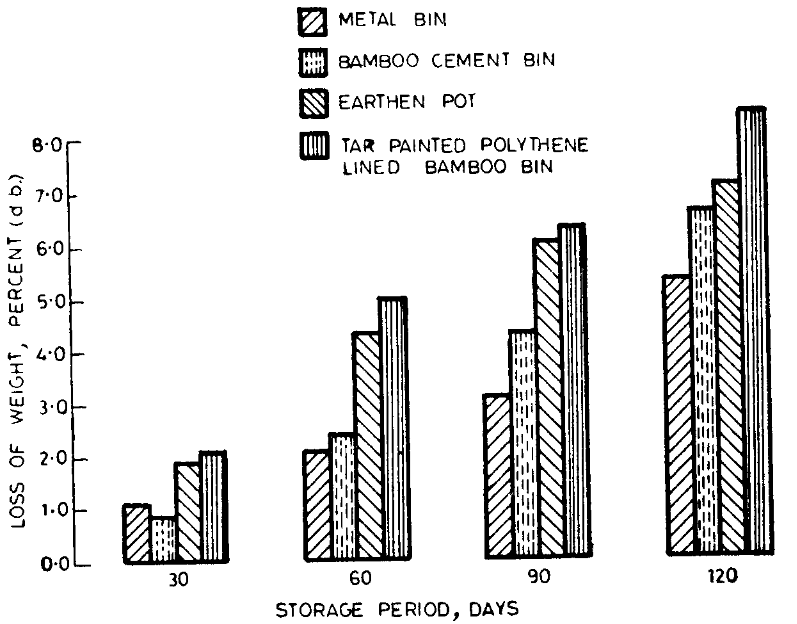


Fig. 4.19 Loss of Weight of Groundnut Samples Stored in Different Storage Structures

A laboratory study was conducted at GAU, Junagadh (1988) where whole groundnut pods were stored in Gunny bags, Jute bags, Polyethylene lined jute bags and Metal bins with open heaping as control. The period of storage was 180 days. At regular intervals of 45 days various bio-chemical parameters like moisture content, protein content, oil content, fungal contamination and resultant aflatoxin content were determined. The insect infestation was also observed. Study (Table 4.9) showed that the polyethylene lined bags and metal bins were best for storage of groundnut pods, as these were efficient in preventing losses due to insect and fungal attack. The open heaping method of storage was least resistant to insect in fungal attack followed by gunny bags and jute bags methods of storage.

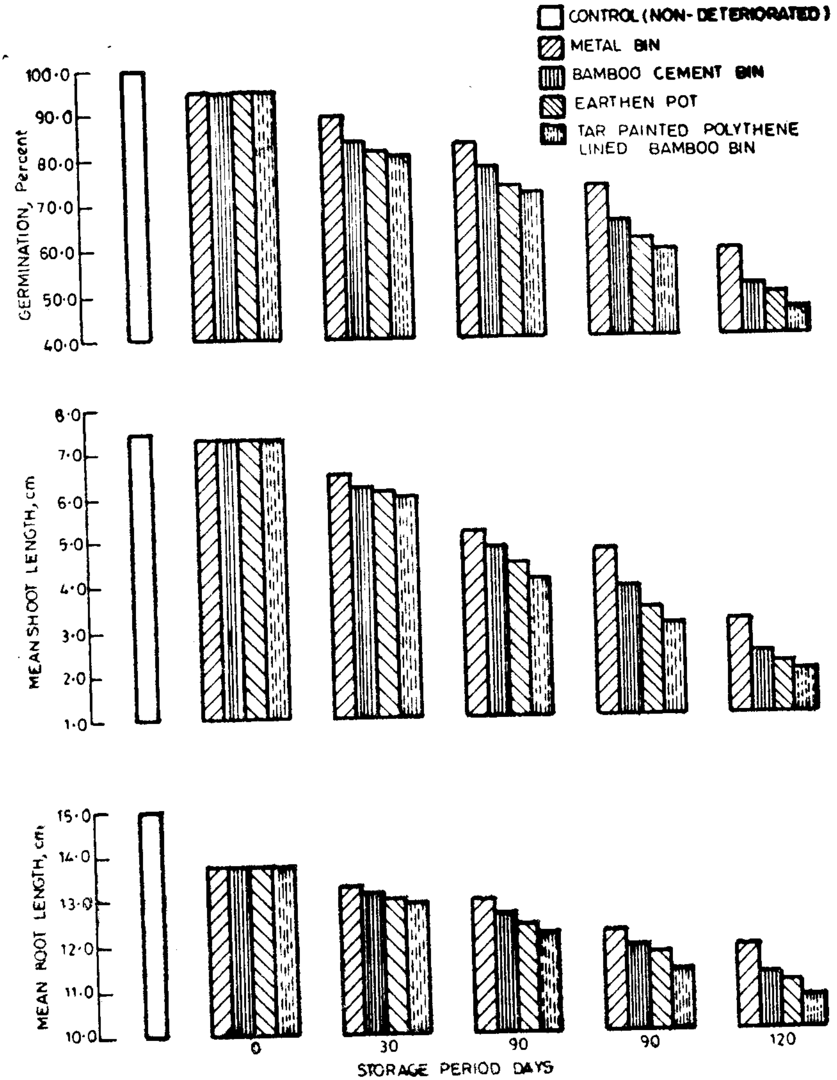


Fig. 4.20 Influence of Storage Period on Root Length, Shoot Length and Percent Germination of Groundnut Samples Stored in Dirferent Storage Structures

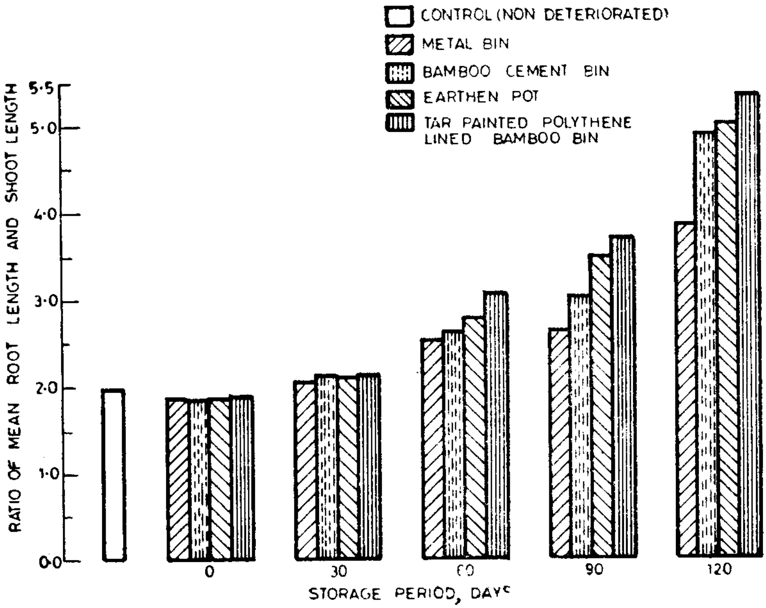


Fig. 4.21 Ratio of Root Length and Shoot Length of Groundnut Samples Stored in Different Storage Structures During the Storage Period of 120 Days

4.6 Control of Aflatoxin

Fungi capable of development on agricultural crops and commodities are ubiquitous and fungal growth is often accompanied by production of toxic metabolites of the common storage fungi *Aspergillus - flavus.* They can produce the carcinogenic toxin under a wide variety of temperatures and humidity conditions. Aflatoxins may, thus, be easily produced and carried from field crop through processing to human food. In light of this, studies have been made for occurrence of aflatoxin in groundnut crop at harvesting stage and storage level of groundnut oil cakes and finding methods of detoxification.

Aspergillus-flavus infestation increases with the increase in storage period and moisture content of groundnut and its cake. More insect infestation and content of impurities also increase the *A-flavus* infestation in groundnut kernels. Aflatoxin, produced by aflatoxigenic strains

Table 4.6 : Variation in electrical conductance, iodine number and saponification value of groundnut stored for 120 d in different storage structures

Storage period d	Electrical Conductance, m, mho				Iodine number, g				Saponification value, mg			
	MB	BCB	EP	TPB	MB	BCB	EP	TPB	MB	BCB	EP	TPB
0	0.16	0.16	0.16	0.16	95.50	95.50	95.50	95.50	192.00	192.00	192.00	192,00
30	0.22	0.25	0.36	0.39	95.80	96.10	97.83	97.96	192.83	192.57	192 88	192.93
60	0.27	0.45	0.58	0.62	95.92	97.09	98.23	98.35	193.01	192.05	194.05	194.58
90	0.30	0.68	0.72	0.78	96.00	97.56	97.98	97.00	193.72	193.89	194.83	194.89
120	0.32	0.75	0.88	0.91	96.45	97.88	97.01	96.23	193.78	193.92	194.00	—

Note : MB – Metal bin
BCB – Bamboo cement bin
EP – Earthen pot
TPB – Tar painted polyethyline lined bamboo bin

Table 4.7 : Variations in Oil and FFA Contents of groundnut stored in different storage structures

Storage period d	Total oil content, % (bd)				Free fatty acid, % (db)			
	MB	BCB	EP	TPB	MB	BCB	EP	TPB
0	53.90	53.90	53.90	53.90	3.55	3.55	3.55	3.55
30	53.78	53.12	52.85	52.93	4.64	4.58	7.33	8.30
60	53.92	53.00	52.52	52.08	5.85	5.93	10.82	11.50
90	53.75	52.95	52.10	51.98	6.70	6.82	10.22	10.89
120	53.69	52.51	52.03	51.46	6.92	7.25	5.42	3.20

Index MB – Metal bin EP – Earthen pot
BCB – Bamboo cement bin TPB – Tar painted polyethylene lined bamboo bin

of *A-flavus* is regarded as most important mycotoxin which is responsible for liver damages and inducing cancer to susceptible animals and man. Investigations carried out by UAS, Bangalore with Spanish improved variety of groundnut has confirmed that the site of *A-flavus* build up is in roots and its zone. Decontamination of root zone and soil may reduce the build up of toxigenic fungi. Studies conducted so far have revealed that storage of groundnut at temperatures below 20°C is not safe if the relative humidity is not brought below 75% as it leads to decrease in nutritional quality and increase in aflatoxin content even if the initial groundnut moisture content is within the safe storage limits. Temperature of 30°C and above are safe for storage when the initial moisture content of the pod is within safe limit and relative humidity is below 65%. Thus the period for which the groundnuts can be stored without effecting the germinability and quality as well as aflatoxin development depends on the temperature and relative humidity during storage.

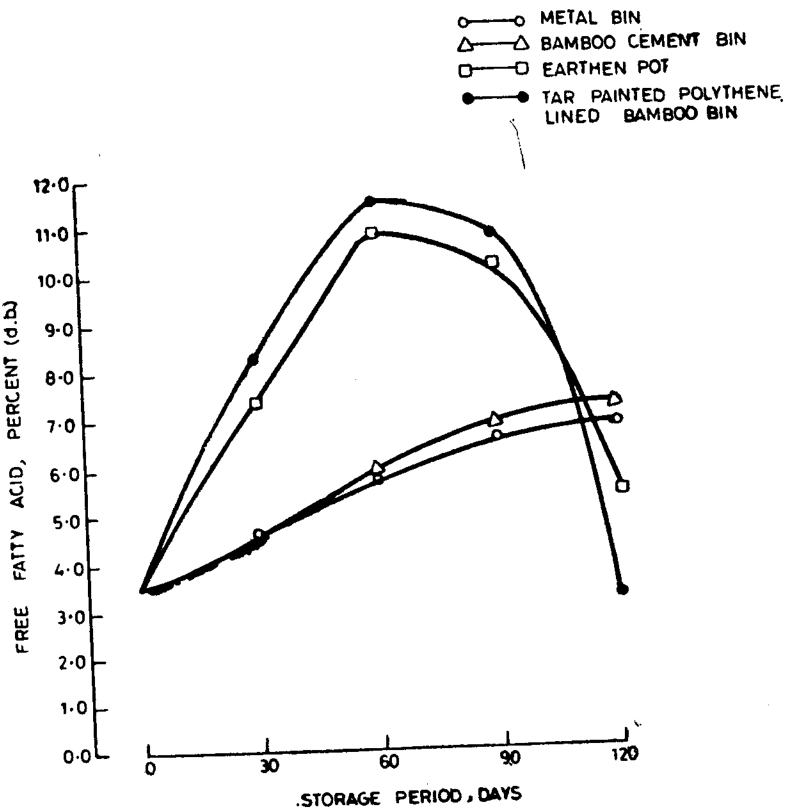


Fig. 4.22 Effect of Storage Period on Changes in Free Fatty Acid Content of Groundnut Stored in Different Storage Structures

Junagadh campus of GAU has analysed the aflatoxin content of groundnut cakes collected from various sources and tried different methods of detoxification ((Table 4 10). Though heat treatment of oil cakes at 135°C for 2 h reduces the aflatoxin content by 87.5%, it also affects the nutritional quality of cakes. Treatment with 5% Hydrochloric acid for 1 h (84.82% reduction) and 6% Hydrogen peroxide for 0.5 h at 80°C (83.33 reduction) have been recommended to be adopted for decontamination of oil cakes from aflatoxln (Annual Report, 1989).

Table 4.8 : Insect infestation in groudnut stored in different storage structures

Storage period d	Storage Structure			
	Metal bin	Bamboo-cement bin	Earthen pot	Tar painted polyeethylene lined bamboo bin
0	No infestation	No infestation	No infestation	No infestation
30	No infestation	No infestation	No infestation	Trace of powder like substance found
60	No infestation	No infestation	Little clot formations with dusty materials	Fairly high extent of clot formations with an undesirable flavour. A few seeds were bored.
90	Trace of infestation started with clot formation	A few numbers of insects were observed with trace of clot formation	Moderately-infested by insects with obnoxious flavour and odour	Severe clot formation associated with fungal attack. Bore formation of seeds with very odd flavour. Moderate insect formation.
120	Powder like substance around seeds with little change in flavour	Lump formation with obnoxious flavour and odour associated with bore formation of seeds	Severely infested and severe clot formation started, half seed bored, fungal attack noted.	Heavily infested, severe clot formation, fungal attack, seeds bored, toxic flavour, dusty materials stored at the bottom of storage structure.

Table 4.9 : Variation in moisture content, insect infestation, oil content and protein content of groundnut during 180 days storage in various structures

Storage structure	Moisture content %		Percent damage		Oil content, %		Protein content, %	
	initial	180 d	initial	180 d	initial	180 d	initial	180 d
1. Open heaping	4.8	11.2	Nil	8	48.1	43.8	27.7	23.9
2. Gunny bags	4.7	9.9	Nil	6	48.2	44.6	27.6	24.9
3. Jute bags	4.6	9.7	Nil	2	48.0	44.6	27.8	25.1
4. Polyethylene lined bags	4.8	5.2	Nil	Nil	48.2	47.3	27.7	26.8
5. Metal bins	4.8	6.1	Nil	Nil	48.1	47.2	27.6	26.5

Ammonia treatment at above 1.5% level removes the aflatoxin completely in groundnut cake but it becomes unpalatable for animal consumption. However, treatment of cake with 1% ammonia removes 75% aflatoxin and cake is also suitable for animal feed.

Table 4.10 : Percent reduction in aflatoxin content in groundnut by various methods of detoxification

Method	Aflatoxin content ppb/kg		Reduction %
	initial	final	
Heating at 135°C for 2h	8×10^3	1.0×10^3	87.5
Treatment with hexane and ethanol (79:21) for 1h	10×10^3	2.0×10^3	80.0
Treatment with hexane, ethanol and water (82:12:13) for 1h	12×10^3	3.0×10^3	75.0
Treatment with 1% calcium chloride for 1h	11×10^3	4.0×10^3	63.64
Treatment with 1% sodium bicarbonate for 1h	9×10^3	5.0×10^3	44.44
Treatment with 6% hydrogen peroxide for 0.5 h at 80°C	12×10^3	2.0×10^3	83.33
Treatment with 2% sodium hydroxide for 24h at normal temperature	11×10^3	2.0×10^3	81.22
Treatment with 5% hydrochloric acid for 1h	13×10^3	2.0×10^3	84.82
Treatment with 2% sodium chloride for 1h at 80°C	12×10^3	5.0×10^3	58.33

4.7 Oil Expression

Oil expression is the mechanical expulsion of oil from an oil seed. Traditionally bullock operated ghanis are used for groundnut. Such ghanis are usually constructed of wood with the exception of a small iron band fixed around the top edge of the mortar. From design aspects, these ghanis have engineering concepts and are evolved keeping in view the local raw material availability, chemical characteristics of oil seeds, local setups etc. Inspite of its divergent characters such as size, structure, area occupied etc, the traditional ghanis prevalent in different regions are constructed in the uniform basic design of mortar and pestle and exerting pressure on oil seed on leverage principal. Only the facher and lat have divergent characteristics. The pressing method of various oilseeds differ from place to place. The traditional oil ghani, operated by bullocks has capacity of 6-10 kg/ charge (daily crushing capacity 60-80 kg) of 90 minutes and requires a floor area of 36 m^2 (400 sq. ft). Fig 4.23 shows such traditional bullock operated ghani.

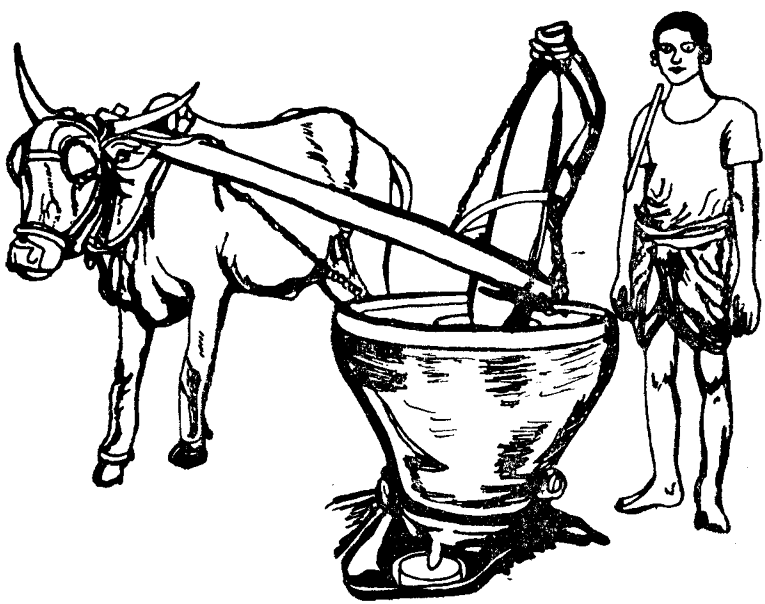


Fig. 4.23 Traditional Bullock Operated Ghani

KVIC introduced the power ghani in 1971-72 to replace the bullocks and increase the productivity. However, while introducing such intermediate technology, the main equipment remained unaltered and only the bullock was replaced with electricity as motive power which increased the yield by about one percent and reduced the time for crushing by 20%. It also reduced the cost of motive power to the extent of 80% in terms of maintenance of animals. The improved overhead power ghani, shown in Fig. 4.24 can crush 100 kg groundnut seed/d with an average capacity of 12-15 kg seed/charge of 60 minutes each. This improved ghani mostly consists of iron drums, wooden fotcher and wooden lat. However, the ghanis can be fitted in concrete or wooden mortar instead of iron mortar. The overall floor area required for this improved ghani is 7.2 sq m (80 sq ft). Fig 4.25 shows the cross section of improved ghani.

KVIC has further designed a portable power ghani (Fig. 4.26) having following specifications and test results,

Power source	:	2 hp, 3 phase motor
Dimensions	:	1.2 m × 1.12 m × 1.50 m
Capacity	:	12-15 kg seed/charge of 50 min or 115 kg/d
Percentage yield	:	40-47% for groundnut, 25-33% for rapeseed/mustard, safflower 48-50% (kernel), sesamum 40-45% and cocount 60-63%.
Labour requirement	:	One

Table 4.11 compares the performance of bullock drawn improved ghani, over-head power driven ghani and portable power ghani for expelling oil from groundnut.

Studies have been conducted at GAU, Junagadh for performance evaluation of power ghani which showed that about 700 cc hot water (temp. 60°C) needs to be applied in 9 kg groundnut seed (mixed with 55 g shells) for good oil recovery in 48-52 minutes batch. The percentage oil recovery was about 38-39% from seed containing 48% oil

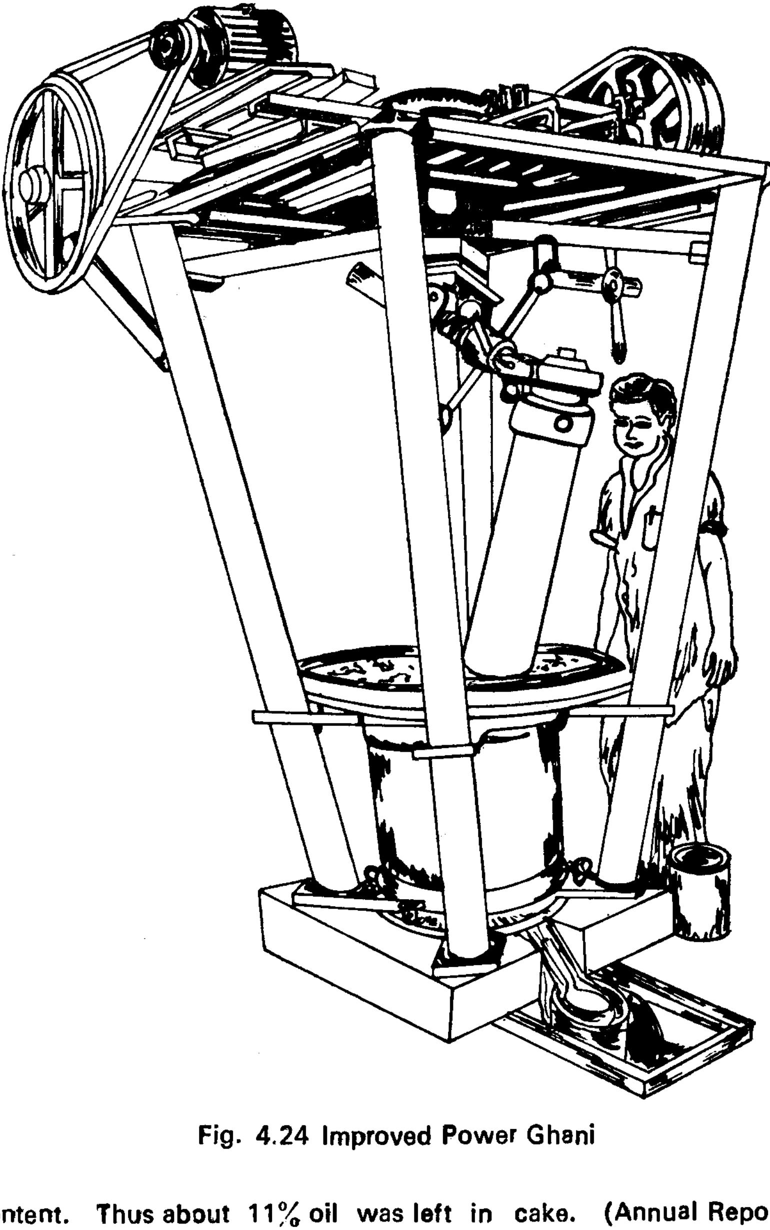


Fig. 4.24 Improved Power Ghani

content. Thus about 11% oil was left in cake. (Annual Report of PHTS, 1981). Further studies on this aspect were carried out at CIAE, Bhopal where groundnut treated with water at 25°C and 80°C with

Table 4.11 : Comparative performance of different types of ghanies used for expelling groundnut

Test Results	Bullock drawn improved ghani	Overhead power ghani	Portable power ghani
Floor space required, sq. m	36.00	7.20	3.24
Capacity/charge, kg	6-10	12-15	12-15
Crushing time/charge, min	90	60	50
Crushing capacity kg/d (8h)	69-80	100	115

Source : KVIC, Bombay.

batch capacities of 12, 15 & 18 kg were used for extraction (Singh, 1983). Untreated kernels did not yield oil. Figures 4.27 and 4.28

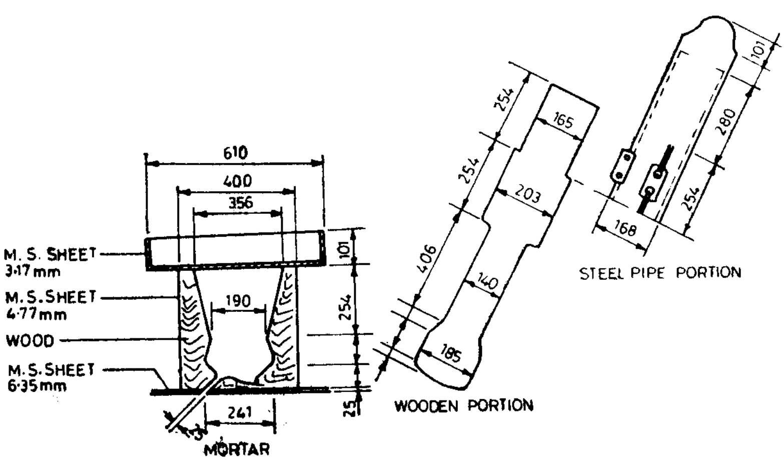


Fig. 4.25 Details of Power Ghani

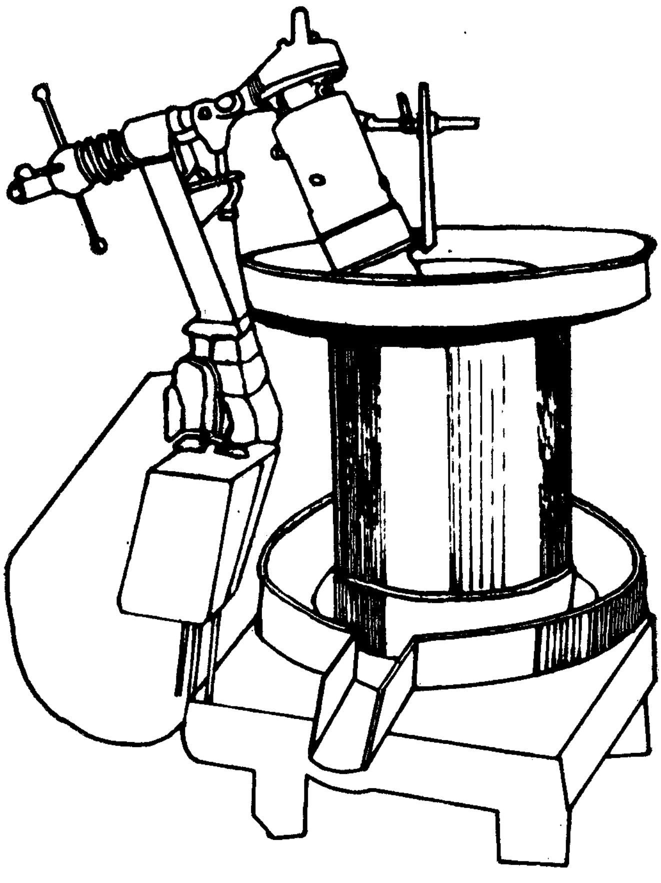


Fig. 4.26 Portable Power Ghani (Right Side View)

show variation of oil yield and energy consumption with quantity of oil seed per batch and variation of oil cake and time of operation with quantity of oilseed per batch respectively with respect to two other treatments namely mixing of cold and hot water. While the percentage of oil extraction in the three cases ranged between 30 and 31%, the energy consumption per kg of kernels crushed was minimum in case of 18 kg batch. The percentage of oil extraction in case of water treatment was around 36% as compared to 31% for tap water treated kernels. Clearly the hot water treatment resulted in increased oil extraction by about 5%. Energy consumption was minimum in case of 18 kg batch capacity. The percentage of oil left in cake was about

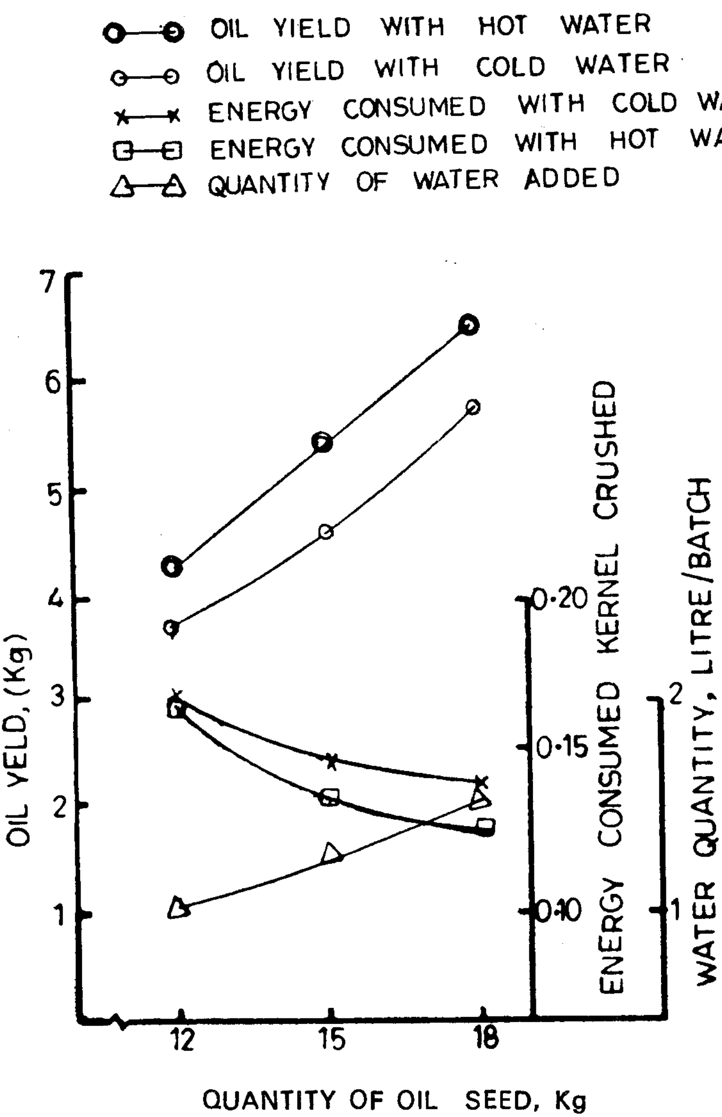


Fig. 4.27 Variation of Oil Yield and Energy Consumed with Quantity of Oil Seed Per Batch with Respect of Two Different Treatments

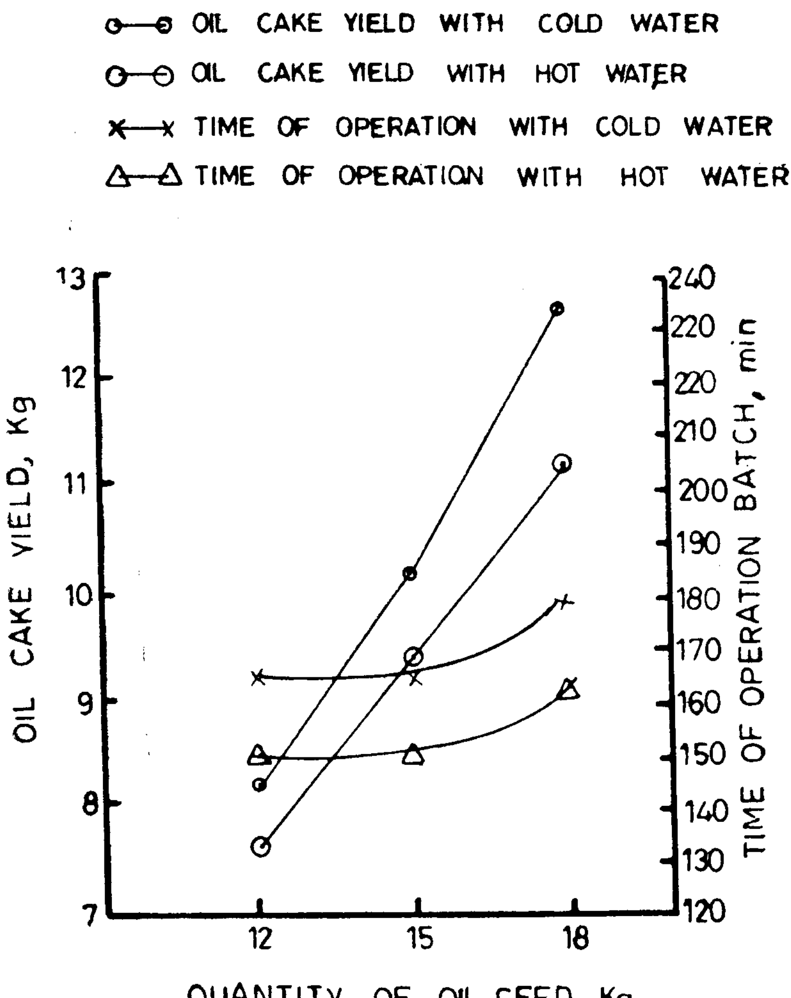


Fig. 4.28 Variation of Oil Cake and Time of Operation with Quantity of Oil Seed per Batch with Respect to Different Treatments

19% (Kernel wt. basis) in case of tap water treatments and about 14% in case of hot water treatment irrespective of the batch capacity.

GAU, Junagadh has also evaluated the performance of a mini oil expeller fabricated by M/s Super Machinery, Rajkot. The expeller and its worm shaft are shown in Figures 4.29 & 4.30. The expeller basically consists of a seed container, oil extraction unit, reciprocating pump, filter unit, boiler and electric motor of 7.5 hp. The capacity of container is 35 kg but for proper application of steam, only 10 kg seeds should be filled. The worm unit is covered with iron strip box which are provided with hair line grooves. It has a power transmission system made of pulleys and gears. The power is transmitted from the main shaft to the expeller unit through these pulleys. The speed of the worm unit is 45 rpm. Locally the extraction unit is known as "four bolt unit" because of the four bolt joining the strip box. The bolts indicate the length of expeller unit. Larger the number of bolts, longer, is the length and more is the extraction capacity. Filter unit consists of 12 plates which are lined within thick canvas cloth. There is a provision of taps at every plate from where the filtered oil comes out and is collected in a tray. The capacity of vertical baby boiler is 8-10 l/h and it is operated under a pressure of 1-1.5 kg/sq cm. Heating is done with the help of groundnut shells (5-6 kg/h) burnt as fuel in the furnace.

Steaming of seed at 1.05-1.4 kg/cm^2 brings the initial moisture content of seed to the level of 5.95% (db). The seeds were mixed with 0.5 kg shells per 10 kg batch. The study showed that under normal clearence of 4 mm, the oil recovery from groundnut seeds was 38%. However, the expeller has not been recommended for groundnut due to blocking of the seed cake at regular interval in the expelling unit as well as at the point of cake outlet (Annual Report of PHTS 1985, 1986, 1987).

Studies have been conducted at CIAE, Bhopal for use of Mini-40 screw press for expression of oil from groundnut. The expeller (Fig. 4.31) consists of a feed hopper, three major sub assemblies namely; worm shaft-operating screw assembly, feed, barrel and choke assembly and main frame-drive assembly. Fig. 4.32 gives the details of worm shaft of this screw press. The power is transmitted with the help of a chain drive arrangement from a 2.2 kW (3 hp) electric motor. Goundnut seeds at 5, 7, 9, & 11% moisture levels were used for oil

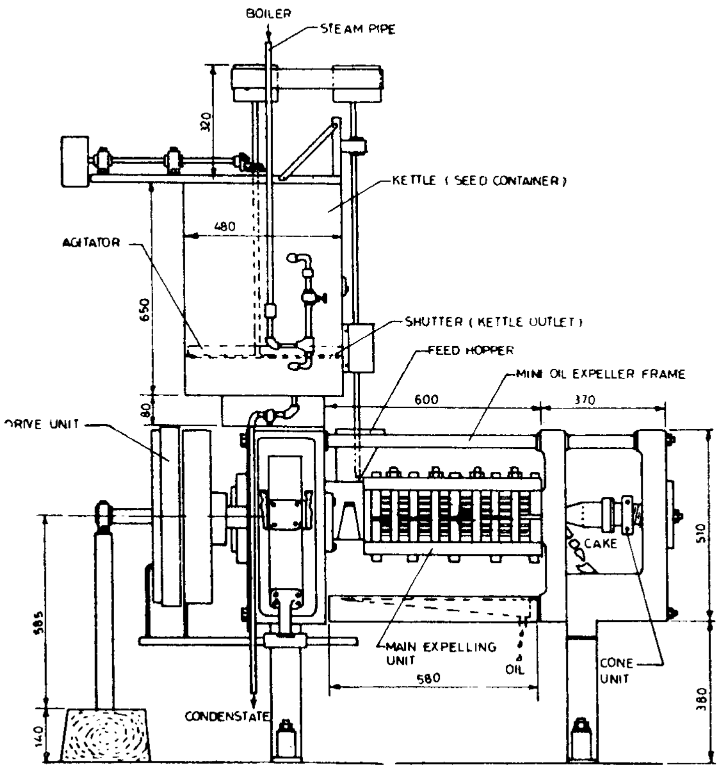


Fig. 4.29 Mini Oil Expeller (Super Model)

extraction. Best recovery of 55.11% (oil basis) was obtained at 5.13% moisture level. However, the expeller was not found suitable for groundnut due to low capacity and unfavourable cost - economics (Annual Report of PHTS. 1987, 1988).

4.8 Storage of Edible Groundnut Oil

All vegetable oils are, to a certain extent, susceptible to chemical changes resulting from processes such as hydrolysis, autoxidation, polymerisation, pyrolysis and uptake off lavours of foreign origin. These chemical changes may occur during production, processing, storage and certain culinary treatments and are mainly influenced by moisture, light, heat, atmospheric oxygen, metal, salts and certain enzymes.

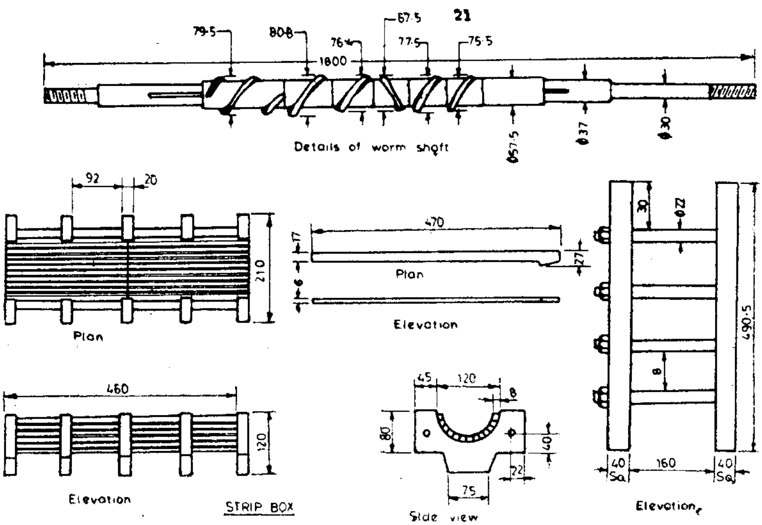


Fig. 4.30 Details of Worm Shaft and Strip Box of Mini Oil Expeller

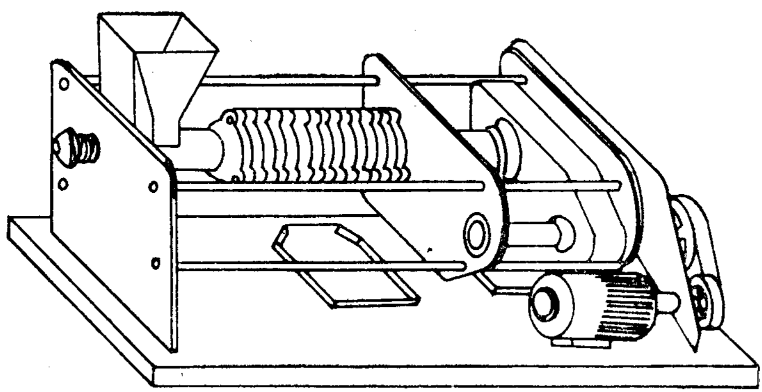


Fig. 4.31 Mini-40 Oil Expeller

The nature and extent of these changes depend very much on the kind of oil/fat and the treatment it receives during production, refining, storage and frying operations. The chemical changes not onty result in off-flavours and decreased organoleptic quality of oil but also to a considerable extent effect its nutritive properties.

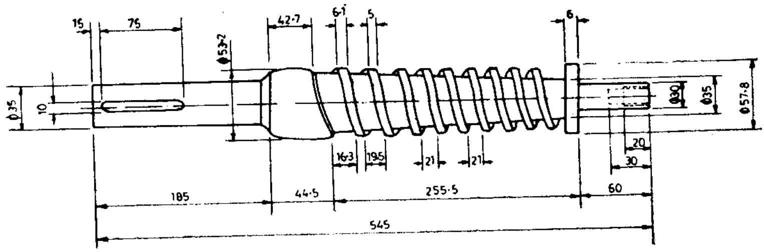


Fig. 4.32 Details of Worm Shaft of Mini-40-Screw Press

In our country, the vegetable oils are stored under various types of climatic conditions, ranging from hot humid to hot-desert climates and considerable time is required in various trade channels before the oil reaches to the consumers. Since the storage climates are most favourable for autoxidation and rancidification, detailed studies on chemical changes that take place during storage and also during subsequent culinary practices employed, are very useful.

With above discussed points in mind, various studies have been carried out to stydy the storage characteristics and suitability of different types of packaging materials/storage structures for storage of crude and refined groundnut oils as described below.

In the study conducted at CIAE, Bhopal, fresh crude groundnut oil, was stored in plastic, glass and tin containers at 10°C, 40°C and ambient temperatures ranging between 12.5 to 34°C. The samples were analysed in terms of FFA, acid value and saponification value after 3, 6 and 9 months. The crude groundnut oil had initial FFA value of 2.1038, acid value of 4.1822 and saponification value of 151.22. Fig. 4.33 shows the variations in these bio-chemical parameters of crude groundnut oil stored for 9 months. The FFA value of groundnut oil stored in plastic container increased upto 2.7732 in case of container kept at controlled temperature of 10°C and upto 2.9030 in container kept at 40°C. The FFA value increased from initial level of 2.1078 to 2.8859 for glass container kept at 10°C, upto 3.0693 in case of container kept at ambient temperature and upto 3.0777 in container kept at 40°C. Similarly the FFA value of groundnut oil stored in tin

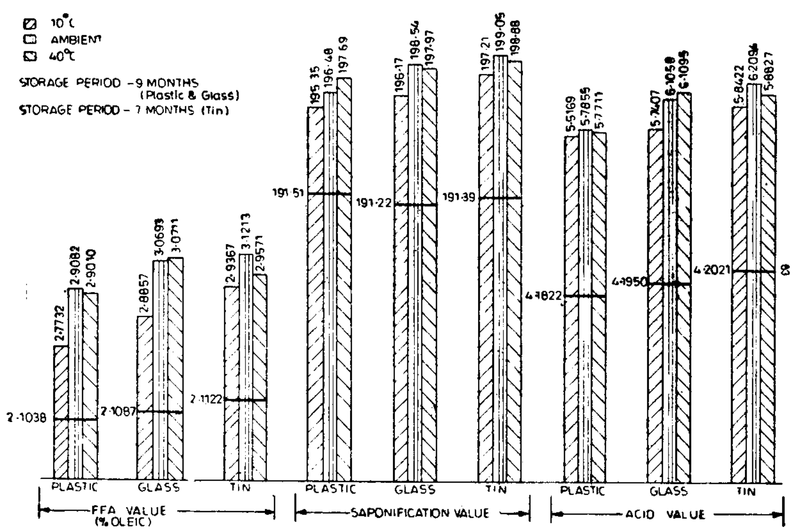


Fig. 4.33 Variation in Bio Chemical Parameters of Groundnut Oil Stored in Various Containers at Different Temperatures

container increased from 2.1123 to 2.9367, 3.1213 and 2.9571% respectively for storage temperatures of 10°C, ambient temperature (between 12.5 to 34°C) and 40°C. Table 4.12 shows the percent increase in FFA and other parameters during the 9 months storage. It may be noted that minimum increase in FFA value of groundnut oil was observed in plastic container followed by glass and tin containers. Similarly minimum increase in FFA value of groundnut oil was observed in oil stored at 10°C temperature in plastic container which increased with increase in temperature of storage showing suitability of 10°C temperature for 9 months storage of crude groundnut oil. As for as acid value was concerned it increased maximum by 1.99% in tin container kept at ambinet temperatures and minimum by 1.33% in plastic container kept at 10°C as shown in Table 4.12. Saponification value of crude groundnut oil increased minimum by 3.84% in plastic container followed by glass container. As for as effect of temperature is concerned, least variations were observed in containers kept at 10°C followed by 40°C and ambient temperatures. The study, thus, showed that crude groundnut oil can be safely stored for 9 months in glass, plastic and tin containers. However use of plastic container and storage temperature of 10°C proved better storage conditions (Srivastava et al. 1990).

GAU, Junagarh has studied the storability of filtered groundnut oil produced by mechanical expression as well as refined and unrefined solvent extracted groundnut oils in tin containers for 5 months period. The changes observed in FFA, acid value, peroxide value and colour index (Lovibond Unit) are presented in Table 4.13. In case of expeller produced filter oil, the increase in FFA value was within ISI (BIS) recommendations but the increase in FFA value of unrefined solvent extracted oil was almost double of that of BIS value. However such increase was marginal in case of refined oil produced by solvent extraction Similar pattern was obtained in case of acid value also. As far as peroxide value is concerned, maximum increase was noted in unrefined oil followed by refined and filtered oils, respectively. The colour index did not increase beyond the BIS values of 10, 20 and 10 respectively for filtered, unrefined and refined oils. It was concluded that the solvent extracted refined oils could be stored for 150 d in above containers without the FFA values, acid values, peroxide values and colour index increasing beyond BIS recommedations. However filtered and unrefined oil can be safely stored for 30-60 days beyond which deterioration in quality occurs (Annual Report of PHTS. 1989).

The same centre of AICRP on Post Harvest Technolgy has also studied the storability of filtered groundnut oil in plastic pouches, polyjar and tin containers for 5 months period. Table 4.14 reports the changes in FFA, acid value, peroxide value and colour index (Lovibond Units). It may be noted that there was a steady increase in FFA content and acid values in all the containers. The increase in these values, was however, whithin acceptable range. The peroxide value increased from initial value of 2.9 to maximum 10.4 in case of tin container while the oil stored in plastic pouches showed least increase of 8.8%. The change in colour index was negligible in oil stored in polyjar where as there was a marked reduction in colour index in case

Table 4.12 : Percent increase in bio-chemical properties of crude groundnut oil during 9 months storage in different containers kept at different storage temperatures

Container	Bio chemical property and storage temperature, °C.								
	FFA, % increase			Acid Value, % increase			Saponification Value, % increase		
	10°C	Ambient	40°C	10°C	Ambient	40°C	10°C	Ambient	40°C
Plastic	0.67	0.80	0.80	1.33	1.60	1.59	3.84	4.97	6.18
Glass	0.78	0.96	0.96	1.55	1.91	1.91	4.95	7.32	6.75
Tin	0.82	1.00	0.84	1.62	1.99	1.66	5.88	7.72	7.55

Table 4.13 : Changes in bio-chemical characteristies of different types of groundnut oil stored in tin containers for 5 months

Oil type	FFA value, %			Acid value, %			Peroxide value, mg/1		Colour Index, (LU)		
	Initial	Final	Control (BIS)	Initial	Final	Control (BIS)	Initial	Final	Initial	Final	Control (BIS)
Expeller produced filtered	0.399	0.949	1i0-3 0	0.794	1.888	2.0-6.0	3.10	11.40	6.10	4.6	10.6
Solvent extracted											
(i) unrefined	0.130	0.812	0.4	0.259	1.616	0.8	2.91	14.80	11.6	10.7	20.0
(ii) refined	0.050	0.378	0.25	0.010	0.752	0.5	0.45	5.60	4.5	4.6	10.0

of oil stored in tin container. The change in case of oil stored in plastic pouches was at par with that of poly jar.

Jayaraman et. al (1976) have studied the suitability of commercially available PVC bottles of 2-l capacity for long term storage of refined groundnut oil. Table 4.15 reports variations in some biochemical characteristics of oil during 30 days storage at 55°C, showing no appreciable difference in these characteristics. A similar study has been conducted by Srinivas Gopal et. al (1976) in which GI drums and high density polyethylene jery drums, both of 20-l. capacity were tried in order to find out a suitable substitute for the currently used 18-l. square tins which suffer in-transit damage and consequent loss of oil by leakage during transportation and storage. Refined and hydrogenated groundnut oils were stored at 37°C in these two containers for 12 months. It was concluded that the oils did not suffer colour change and the chemical changes were negligable.

Arya et. al (1976) have studied the chemical changes taking place in refined groundnut oil, fortified with vitamin A, stored in three types of climatic conditions (cold, hot-humid and hot dry) for a period of two years. This study conducted at Madras, Simla, Panitola and Jodhpur showed that refined groundnut oil remained in acceptable condition for a period of one year (Table 4.16). Maximum vitamin losses were 17% after 6 months and 30% after one year. The losses were maximum in samples stored in hot region indicating a relationship between peroxidation and vitamin A destruction. Addition of Embanox-6 suppresed both, peroxidation and vitamin A destruction considerably.

4.9 Utilization of Groundnut Cake

Groundnut cake, a by-product of oil industry, is rich in protein. Because of its drak colour due to the presence of red skins and bitter taste because of saponins present in the hearts ie. germs of groundnut, the cake, despite high protein value is not considered fit for human consumption and is mainly used as cattle feed and partly as manure. In order that the cake could be used as a good protein supplement in food products, OTRI (now called as JNTU.), Anantpur has developed processes and equipment for decuticling and degerming which enables

Table 4.14 : Changes in bio-chemical characteristics of filtered groundnut oil stored in various containers

Storage container	Bio-chemical Properties/Storage days										
	FFA, (%)			Acid value, %			Peroxide value, mg/l		Colour index, LU		
	0	150	Control values (BIS)	0	150	Control values (BIS)	0	150	0	150	Control values (BIS)
Plasitc pouches	0.400	0.969	1.0–3.0	0.796	1.928	2.0–6 0	2.9	8.8	6.0	5.0	10
Poly jar	0.410	0.963	1.0–3.0	0.816	1.916	2.0–6.0	3.0	10.0	5.8	5.8	10
Tin	0.425	0.964	1.0–3.0	0.846	1.918	2.0–6.0	2.9	10.4	6.0	4.3	10

Table 4.15 : Changes in characteristics of refined groundnut oil stored in PVC bottles at 55°C

Bio-chemical characteristics	Storage days			
	0	15	20	30
Iodine value	84.0	86.5	88.2	90.2
Peroxide value	1.9	2.6	2.9	3.2
FFA %	0.14	0.16	0.20	0.22

Table 4.16 : Changes in selected bio-chemical characteristics of refined groundnut oil stored under different climatic conditions

Location of Experiment & Sample type	Characteristics/Storage period					
	FFA, %		Peroide value, milliequivalents of O_2/kg fat		Vitamin A, % decrease	
	6 month	12 month	6 month	12 month	6 month	12 month
Madras						
(i) Refined oil	0.11	0.20	9.5	27.7	11.7	24.1
(ii) Refined oil + 0.1% Embonox-6	0.10	0,20	5.6	15.2	9.4	14.0
Simla						
(i) Refined oil	0.10	0.14	8.9	13.2	10.7	22.4
(ii) Refined oil + 0.1% Embonox-6	0.10	0.20	4.8	5.1	9.4	16.0
Panitola						
(i) Refined oil	0.12	0.14	10.6	23.8	10.6	22.6
(ii) Refined oil + 0.1% Embonox-6	0.12	0.14	7.4	10.2	10.0	16.0
Jodhpur						
(i) Refined oil	0.12	0.16	11.6	31.1	14.6	29.3
(ii) Refined oil + 0.1% Embonox-6	0.12	0.16	8.2	11.3	11.4	15.6

Initial values—FFA : 0.08, Peroxide value : 4.1 and Vitamin A-700 IU in getting a cream-coloured cake without bitter taste. This cake can be converted into flour meant for food processing industries such as protein-fortified wheat flour, protein-rich bread, biscuits and confectionary.

The processes developed by JNTU, Anantpur are covered under separate patents as described blow.

Process 1 : Indian Patent II 9586

The process comprises of passing the size-graded and roasted groundnut between two vertically mounted discs, made of wood or hard rubber or similar material, facing each other one of which is stationary and the other mechanically rotating at a revolution per minute in the range of 500-1,400 and thus subjecting the seed to rubbing action due to which the skins are peeled off from the kernels and the kernels split into their constituent halves which facilitates the knocking off the hearts or germs, partly or wholly and separating the constituents of the mixture (decuticled and degermed kernels, skins, hearts and any powdery material) form one another by means of sieving in a shaker separator with pneumatic aspiration. Separation of the constituents of the mixture may also be carried out making the mixture coming from the decuticler to fall on an inclined plane at the base of which is a fan. While decuticled splits and some free germs slide down the plane and fall to ground, tight cuticles and fine powder, if any, will be blown away by fan.

Process 2 : Indian Patent 120405

The process of feeding the size-graded and roasted groundnut kernels to an assembly of machines essentially comprising of a roller type beater, a trough-like grate formed of perforated sheet or flats or round bars with springs between each and a fan blower. The kernels an soon as they fall into the trough are rubbed by the revolving beater against the grate and are instantly decuticled and instantly split into two natural halves from which the germs are knocked off during the operation. The decuticled and degermed splits, germs, and cuticles are mmediatly forced down through the openings in the grate into an inclined plane (placed directly below the grate). The light materials like cuticles, fine powder, if any, are blown away by a fan to fall behind the machine while the decuticled and degermed kernels and some germs come down by gravity from the inclined plane and are collected in front of the machine.

Equipment

	Indian Patent 119586	Indian Patent 120405
i) Equipment	a) Seed cleaning and grading equipment	a) Seed cleaning and grading equipment
	b) Roaster	b) Roaster
	c) Disc huller with shaker separator and cyclene separator, etc.	c) Disc huller beater with grate, fan, inclined plane, etc.
ii) Power required per tonne of the kernel produced	10 KWh	10 KWh

The description of these equipment used for above is given below :

(1) Continuous belt type groundnut decuticling and degerming machine.

Name of the machine : Decuticling and degerming machine.

Purpose of the machine : To decuticle and to degerm groundnut kernel.

Description of the machine : The equipment consists of three rollers over which an end less belt of rough texture is moving. The tension of the moving belt can be varied by adjustment of the middle roller. The rollers operate at a surface speed of 75 metres per minute. Another belt is fixed over the moving belt in such a way that one end of it is tightly attached to an adjustabte mild steel flat while the other end traverses the surface of the equipment over the moving belt and left loose with provision to hang weights in order to increase or decrease the tension of the stationary upper belt. The machine works mechanically and continuously with 0.5 hp motor.

Test data : The skin removal was found to be 90% and germ removal was 60 percent. The capacity is 2 tonnes per day.

Disc huller type groundnut decuticling and degerming machine

It is a disc huller with wooden discs. One of the discs is static and the other rotates at a speed of 600 rpm by a 15 hp motor. The clearence between the surface of the discs can be varied. A shaker separator with suitable screens and a cyclone separator are synchronized with the machine to get a continuous performance. The capacity of the machine is 8 t/d with 99% decuticling and 95% degerming under optimum conditions of clearence, screen arrangement and cyclone separation.

Roller type groundnut decuticling and degerming machine

The machine comprises of a beater having horizontal channel grooves and with or without steps around its surface This beater rotates co-axially along a grate which has a semi circular shape and In the form of a trough and is formed of a perforated sheet or a number of mild steel flats placed horizontally on their edge or mild steel round bars with the spacings between each adjusted to the desired width. The clearence between the grate and roller may be such that the roller rotates freely without any obstruction from the grate. An inclined plane is fixed directly below the grate. The plene may be with or without perforations and may be a stationary or a shaker type. A fan is fixed towards the downward slope of the inclined plane. The beater and the fan can be driven either manually or mechanically. The capacity of the machine is 12 t groundnut kernel/d. with 95% decuticling and 70% degerming efficiency.

Roller type combined groundnut decorticating, decuticling and degerming machine

It is a conventional groundnut decorticator with suitable modifications to suit the purpose. The capacity of the machine is 8t/d with 100% decortication, 97% decuticling and 92% degerming. The yields are decuticled and degermed seed-68%, germs and grits-4% and shells and cuticles-28%.

Beater type combined groundnut decorticating, decuticling and degerming machine

This equipment comprises of a beater having projecting rods and rotating in a vertical plane coaxially inside a trough. The shells are broken, the cuticles are peeled off, the kernels split into halves and the germs knocked off from the split kernels and separated from the other constituents of the mixed produce by means of a fan blower fixed in the machine. The capacity of the machine is 8 t/d. The degree of decortication is 100%, decuticling 97% and degerming 92%. The yields are decuticled and degermed seed 68%, shells and cuticles 28% and germs and grits 4%.

Groundnut cake has been used at OTRI, Anantpur for preparation of low fat high protein flour of edible grade quality which is further used in Balahar; *poustik atta* etc. For this, the pods are decorticated and sound kernels are roasted, decuticled and degermed as described earlier. Now this product is expelled after mild cooking so that the cake contains 6-7% oil content. The cake is converted into flour by grinding and air classification or sieving.

The deoiled meal of groundnut is reported to contain 10% moisture (max.), 47% crude protein (min.), 1.5% crude fat (max.), 12% crude fibre (max.) and 2.5% acid insoluble ash (max.), (SEA Hand book, 1990).

5. SOYBEAN

Soybean contains about 40% protein and 20% oil. Soy protein is the most economical protein produced in the world. The high quality of soy-protein is illustrated by its content of all the essential amino-acids with the exception of sulphur containing amino-acids. This imbalance is adequately offset in a traditionnal cereal based mixed diet in India. Supplementation of the cereal based diet with soy-protein gives an amino-acid complementation which results in increased protein quality and quantity approaching to that of animal protein.

Although soybean was introduced in India primarily as a protein food crop but it turned out to be a commercial crop exploited for oil while the protein rich meal is exported to be used as animal feed. As of now, India produces about 1.8 million tonnes soybean seeds, 0.088 million tonnes soybean oil and 1.4 million tonnes of oil meals out of which about 1.05 million tonnes of meal is exported (1989–90). annually.

This chapter describes threshing, drying, cleaning-cum-grading, seed treatment. dehulling, milling, blanching, flaking, storage and oil extraction technologies as well as reports about various equipment developed for carrying out these operations. The chapter also reports various technologies developed for utilization of soy protein in different forms.

5.1 Threshing

Crushing of soybean crops with bullock or a tractor for threshing is not suitable. A number of threshers have been developed in India for this purpose which include RAU, Udaipur threshers, GBPUAT, Pantnagar thresher, JNKVV, Jabalpur threshers and CIAE, Bhopal's multi-crop thresher. A comparative study of these threshers is presented in Table 5.1.

CIAE, Bhopal has developed a multi-crop thresher (Fig. 5.1) by incorporating IRRI axial flow arrangement on traditional spike tooth

Table 5.1 : Compartive study of salected soybean threshers

Name of thresher and its location where developed	Type	Specifications and test results		
		Power req, hp	Capacity, kg/h	Cost of equipment, Rs.
Pulse crop thresher, RAU Udaipur	Power operated	5	200-250	NA
Soybean thresher, RAU Udaipur	Power operated, rasp bar type	2	85	NA
Soybean thresher, GBPUAT, Pantnagar	Power operated, rasp bar type	15	700-900	12,C00
Multicrop thresher, JNKVV, Jabalpur	Power operated, peg type	3	300-320	5,000
Single plot thresher, JNKVV, Jabalpur	Power operated,	3	N. A.	N. A.

thresher. The machine is operated by a 5 hp electric motor and consists of a threshing cylinder, concave, blower, sieves, feeding chute etc. Table 5.2 gives the summary of test results of this thresher for soybean at maximum feed rate.

5.2 Cleaning-cum-grading

Cleaners and graders for soybean have been developed at CIAE, Bhopal, IGSI, Hapur and GBPUAT, Pantnagar as shown in Figures 5.2 to 5.5. Table 5.3 presents a comparative study of these cleaners and graders.

5.3 Drying

Soybean responds considerably to the ambient moisture and is prone to shattering if allowed to overdry in the field creating weed

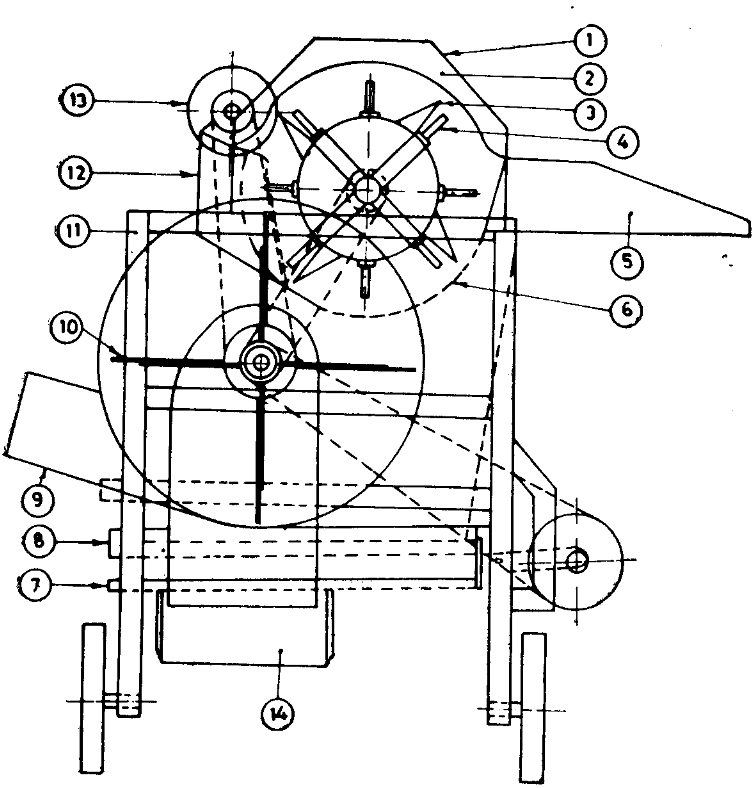


Fig. 5.1 C.I.A.E. Multicrop Thresher

1. Cylinder Drum 2. Louvers 3. Straw Thrower 4. Threshing Cylinder 5. Feeding Tray 6. Concave 7. Lower Sieve 8. Top Sieve 9. Blower Outlet 10. Blower 11. Frame 12. Cylinder Outlet 13. Electric Motor 14. Main Grain Outlet

problem to the subsequent crop besides reduction in effective yield. Moreover, soybeans have special characteristic which causes precipitation to adhere and beans picking up relatively more moisture and dry slowly making it more vulnerable to microbial damage. Also soybeans have 40% proteins and approximately 20% oil which are highly polyunsaturated. Adverse weather conditions cause buildup of free fatty acids (FFA) resulting in low yield of refined oil and denaturation of the

Table 5.2 : Test results of CIAE multi-crop thresher for soybean

Parameter	Test results for soybean
Crop variety	JS 7244
Threshing drum speed, rpm	300
Feed rate, kg/h	560
Out put kg/h	200
Broken grain loss, %	2.20
Blown grain loss, %	Nil
Spilled grain loss, %	0.61
Threshing efficiency, %	98.8
Cleaning efficiency, %	93 0
Cost of machine, Rs.	8,000
Operating cost of machine, Rs/h	8.37
Cost of threshing, Rs/t	42.00

Table 5.3 Comparative performance of cleaners and graders developed for soybean

Equipment/ Developed at	Type	Capacity, kg/h	Power req., hp	Labour req.,	Cost, Rs.	Cost of operation, Rs/t
Hand operated CIAE, Bhopal	Cradle type double screen	150-225	Manual	1	600	10.00
Hand operated/ IGSI, Hapur	Concentric perforated drum	100	Manual	1	600	20.70
Pedal-cum-power operated CIAE, Bhopal	Continuous	350-600	Manual/ 0.5	2-1	3100	6.7
Power operated/ GBPUAT, Pantnagar	Oscillating sieve	300	5	2	7000	44

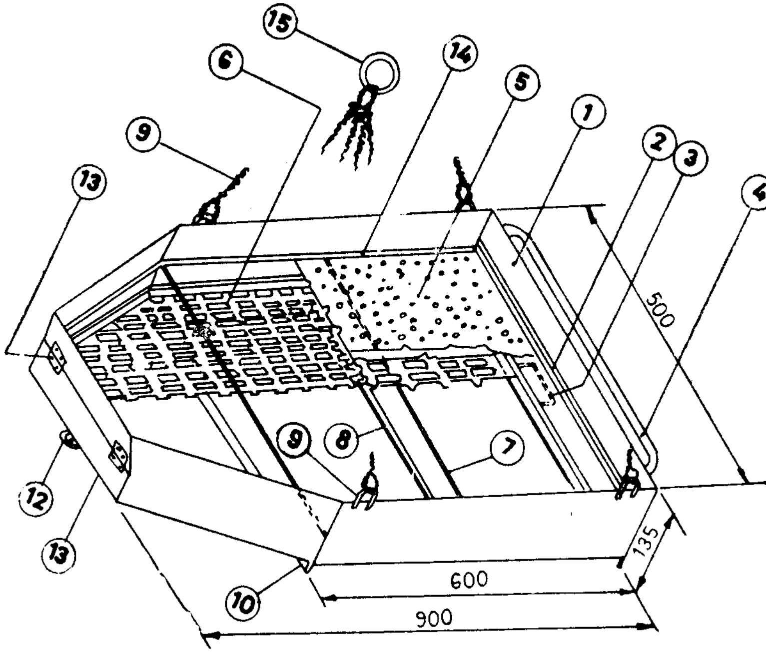


Fig. 5.2 Hand Operated Double Screen Grain Cleaner

1. Screen Frame 2. Draper Rod 3. Screen Angle 4. Handle 5. Scalper Screen 6. Grader Screen 7. Square Bar Support 8. Flat Bar Support 9. Rope Attachment 10. Base Angle 11. Shutter 12. Rope Spring Attachment 13. Hinge 14. Guide 15. Ring For Grading

protein. Similarly soybeans have relatively weak cuticle making it prone to splitting. Split beans have lower commericial value than whole sound beans. These all emphasize the drying of soybean to a suitable moisture content. For minimum loss, the crop needs to be harvested at 15-18% moisture level (wb). Once the 'pod filling' stage of the standing crop is reached, reduction in moisture content is very fast, even to the extent of 43% in 14 days. Thus due to faster drying rate under the ambient air condition, the moisture content is also reduced rapidly. However, during rapid drying phase, steep moisture gradient prevails in the beans of upper and lower portions of the plant

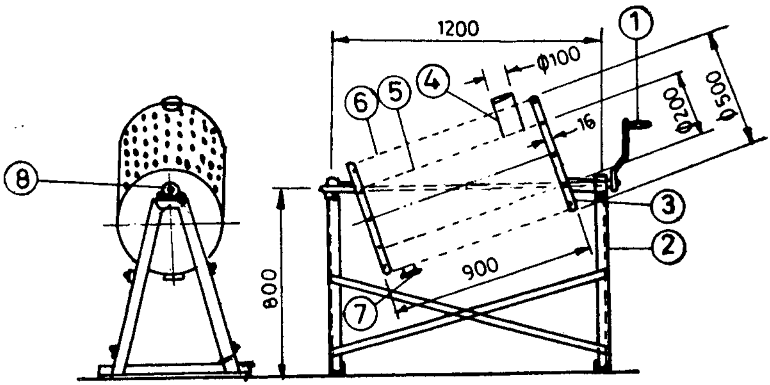


Fig. 5.3 Hand Operated Batch Type Grain Cleaner

1. Handle 2. Stand 3. Lid 4. Inlet with Cover 5. Sieve with Round Holes to Retain Clods Husk Stone Particles Etc. (Hole Size ϕ4) 6. Sieve with Sloted/Small Round Holes of 2mm ϕ Size to Retain Sound Grain 7. Clean Grain Outlet with Cover 8. Bearing Block

All Dimensions are in mm

which disappears once the bean moisture lag is behind ambient moisture by two hours reaching maximum between 6-8 h and minimum at about 16 h. Conventionally soybeans are dried in the field. Heap drying of soybean is not recommended as the grains get infested with fungus (1-1.5%) and germination also gets reduced (92–71%). Moreover, under unfavourable weather conditions of hot, humid overcast weather, conventional practice does not permit drying to safe moisture levels. A prolonged exposure damages the beans and two types of damaged grains are obtained viz; green damaged and field damaged. Green damage occurs due to frost or extreme low temperatures and such beans contain higher percentages of FFA and create problem in oil refining removing green colour. Field damage occurs when matured beans are exposed to rains and damp weather. Such beans turn dark-brown and decay in pods and are more objectionable from processors point of views than green damage.

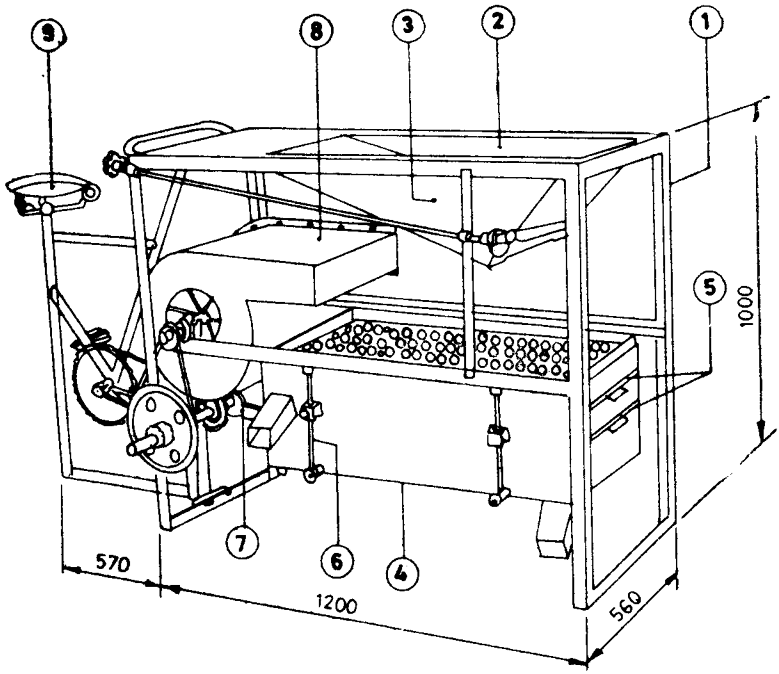


Fig. 5.4 Pedal Operated Air Screen Grain Cleaner

1. Main Frame 2. Hopper 3. Feeding Mechanism 4. Sieve Box 5. Scalping and Crading Sieves 6. Shoe for Sieve Box 7. Eccentric Unit 8. Centrifugal Blower 9. Standard Bicycle Parts

For mechanical drying of soybean and its products, continuous flow heated sand medium drier, tray type natural convection drier, modified natural convection drier and multi-purpose driers have been developed (Fig 5.6–5.9). Table 5.4 presents a comperative study of these driers.

5.4 Seed Treatment

Mixing of some chemicals are recomonded with soybean seeds/grains to improve its germination and storability. GBPUAT, Pantnagar has developed a seed treatment machine for this purpose. The specifications and test results of this machine (Fig. 5.10) are as follows :-

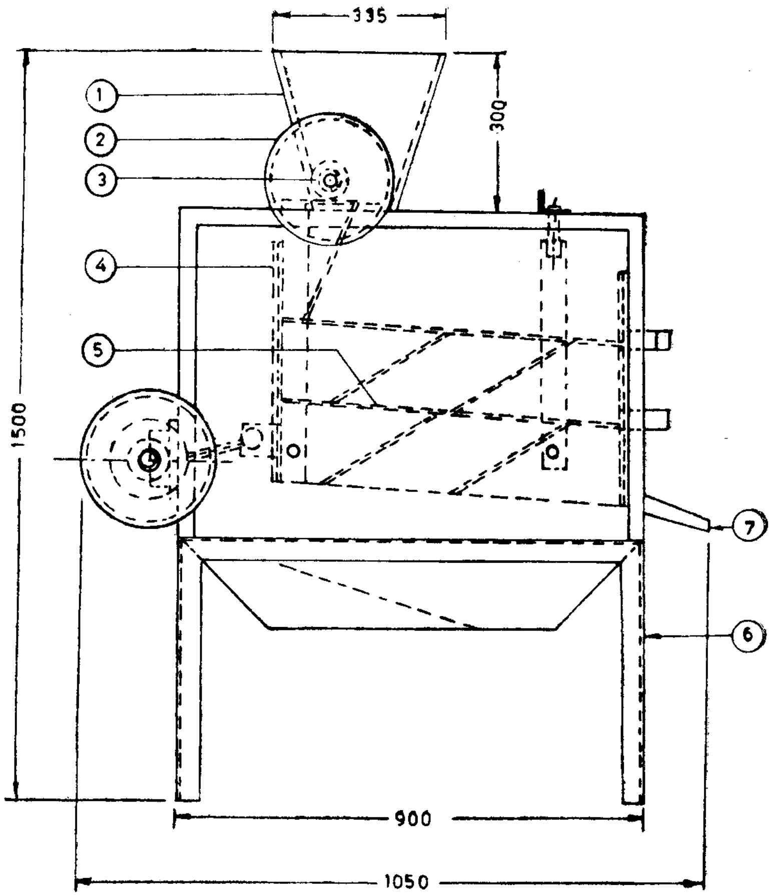


Fig. 5.5 Seed Grader (Power Operated)

1. Hopper 2. Pulley 3. Feed Roll 4. Hanger 5. Sieve
6. Frame 7. Seed Outlet
Dimensions in mm

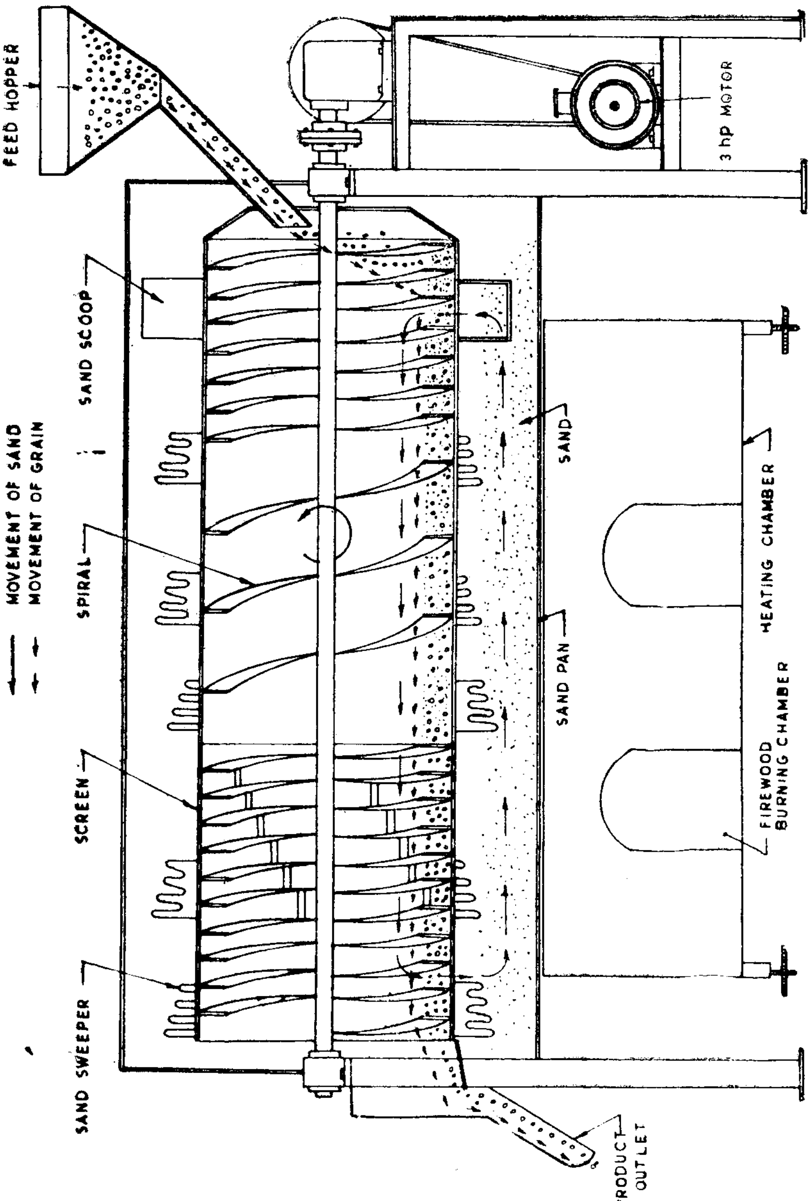


Fig. 5.6 Continuous Flow Heated Sand Medium Drier

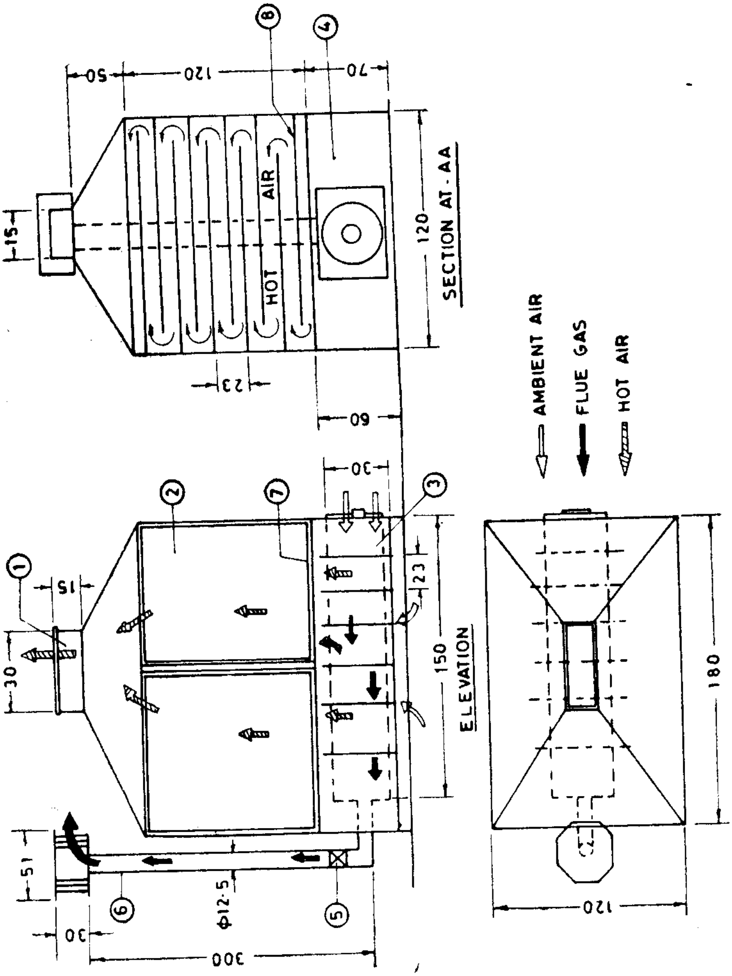


Fig. 5.7 Tray Type Natural Convection Dryer for Soybean
1. Saturated Air Vent 2. Drying Chamber to Accomodate Trays of 90 Cm × 120 Cm 3. Heating Unit
4. Plenum Chambar 5. Butterfly Value 6. Chimney with Exhaust 7. Wire Mesh 8. Wire Mesh Tray.
Dimensions in cm

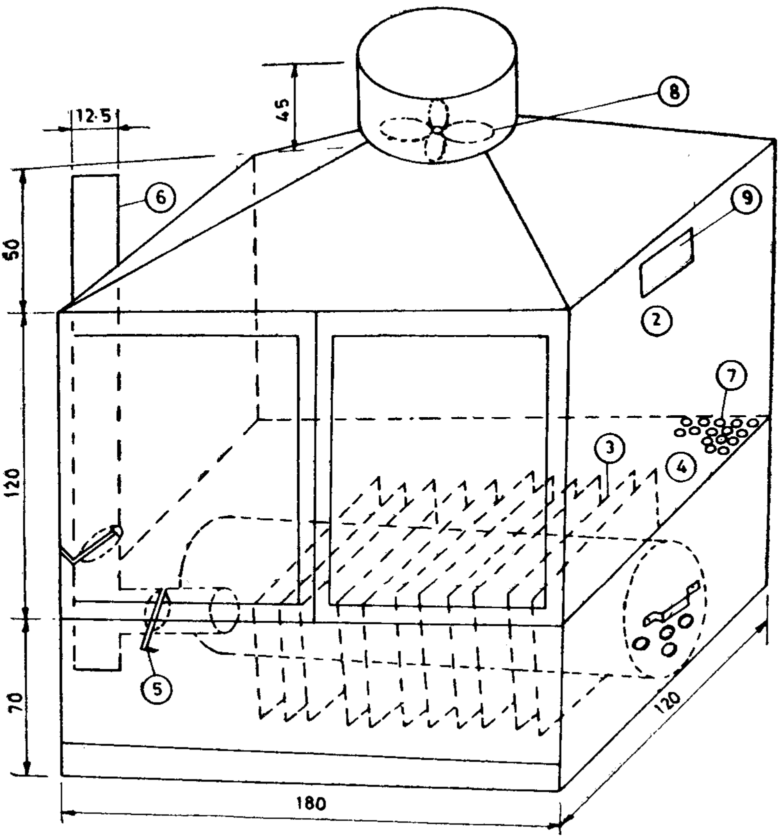


Fig. 5.8 Modified Natural Convection Dryer for Soybean

1. Saturated Vent 2. Drying Chamber to Accomodate 24 Trays of 90 cm × 120 cm 3. Heating Unit 4. Plenum Chamber 5. Butterfly Valves 6. Chimney 7. Perforated Sheet 8. Exhaust Fan 9. Speed Regulator

Dimensions in mm

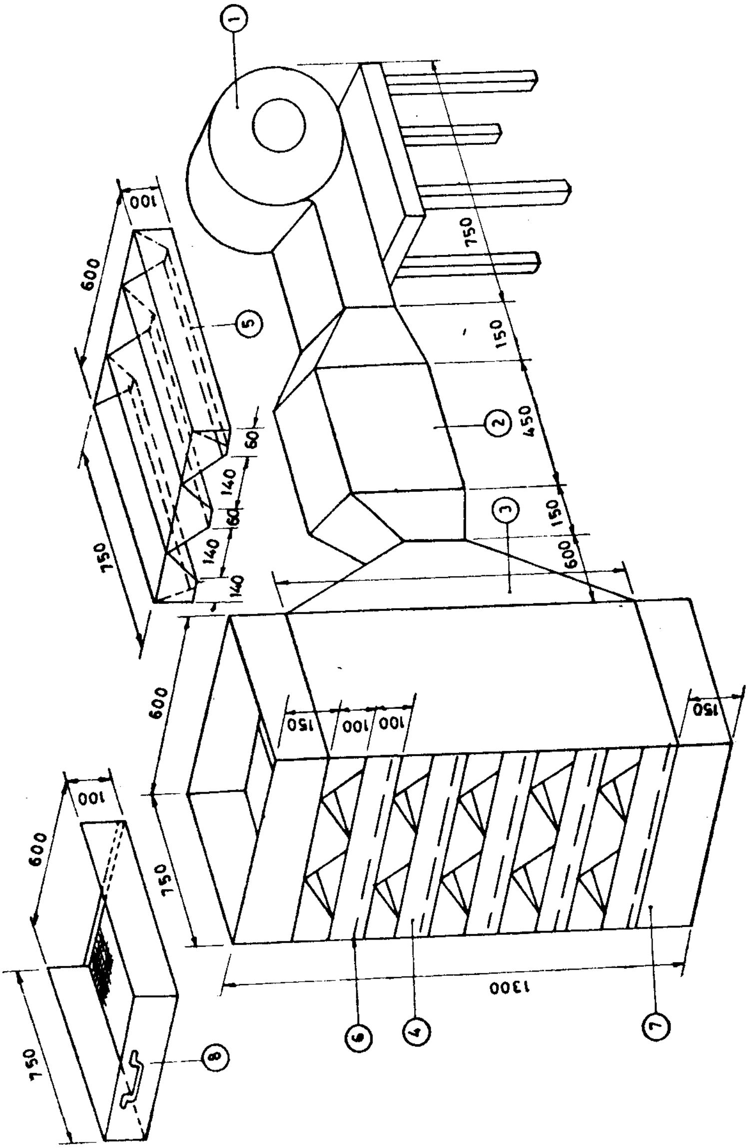


Fig. 5.9 Multipurpose Dryer for Soybean and its Products
1. Blower 2. Heating Unit 3. Plenum Chamber 4. Drying Chamber 5. Baffled Tray for Grain Drying 6. Stopper for Recirculation 7. Grain Collection Box 8. Wire Mesh Tray for Food Product Drying
Dimensions in mm

Type	:	Power operated, continuous gravity feed type
Capacity	:	1000 kg/h
Power requirement	:	1 hp
Labour requirement	:	Two
Cost of equipment	:	Rs. 2,000/-
Cost of operation	:	Rs 21/t of soybean seed

Table 5.4 Comparative study of soybean driers

Drier/ Developed at	Type	Capacity	Power req., hp	Labour req.	Cost, Rs.	Cost of operation, Rs/t
Continuous flow heated sand medium drier TNAU Coimbatore	Power operated, Portable	600–800 kg/8h (soybean)	3	1	10,000	—
Tray type natural convection drier/ CIAE, Bhapal	Natural convection, batch	100 kg/ batch of 6 PS h (soy dal and flakes)	Wood chips (3 kg/h)	1	5,700	852.50
Modified natural convection drier/ CIAE, Bhopal	Natural convection batch type	100 kg/ batch of 12 h (soy dal)	Wood chips (3 kg/h)	1	6,500	679.0
Multi-purpose drier/ CIAE, Bhopal	LSU and batch of 1.75–5h (1.75–5h for flakes and 5 h for seed/ dal)	250 kg/ and 8 kW	2 hp	1	8,000	114.6–258

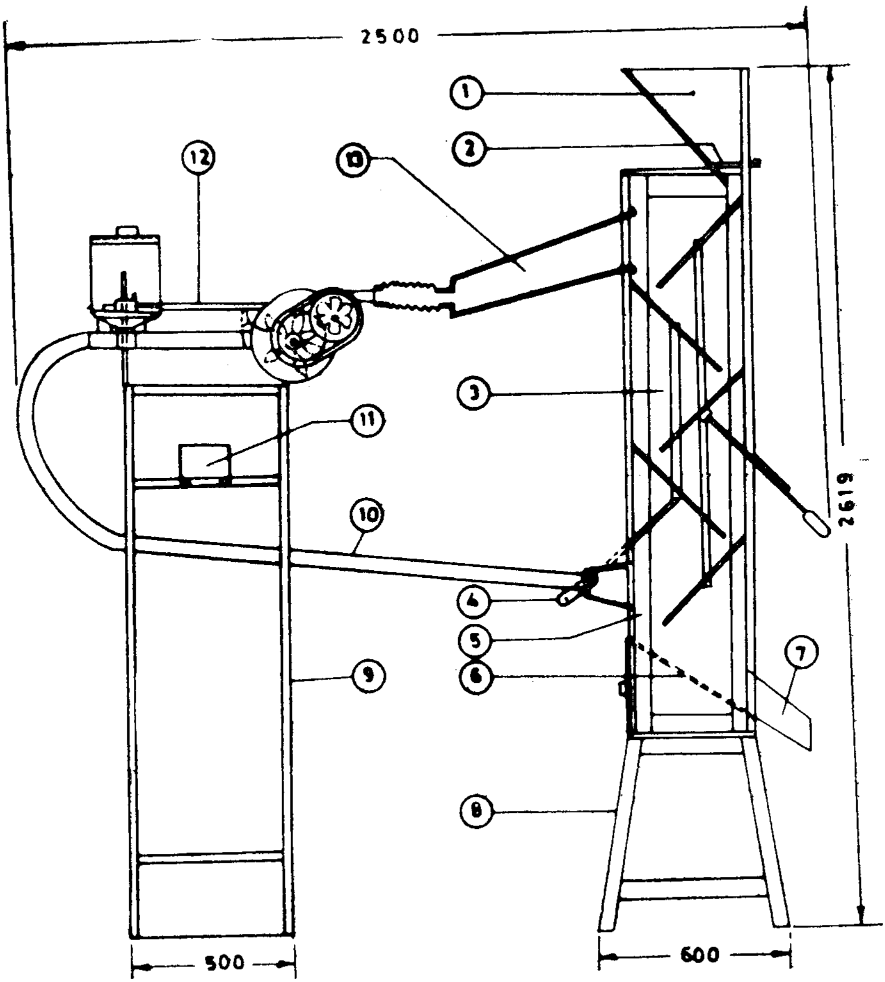


Fig. 10 Soybean Seed Treator

1. Feed Hopper 2. Sliding Plate 3. Baffle Plate 4. Angle Adjusting Lever 5. Mixing Chamber 6. Metal Screen 7. Outlet for Seed 8. Wooden Frame 9. Iron Frame 10. Recirculating Duct 11. Motor 12. Duster 13. Chemical Feeding Duct

Dimensions in mm

5.5 Dehulling

For food uses of soybean, it is essential that its hull content which is about 10% of the weight of beans is removed. Soybean hull is loosely attached with the cotyledons. Simple mechanism of rubbing the soybean seed/grain between two surfaces can detach the hull. Five types of dehullers have been developed for soybean in India. These are rotar concave type, hand grinder, manually operated, power operated and cylinder-cocave type dehullers as shown in Figs. 5.11 to 5.15. Table 5.5 gives comparative description of these dehullers.

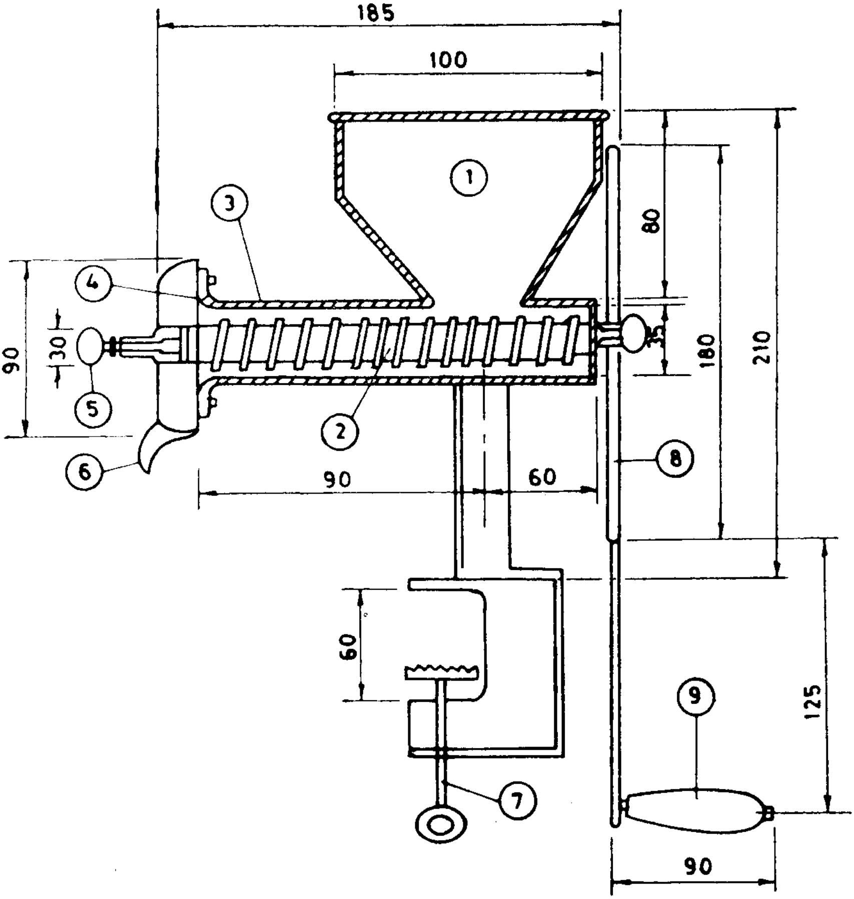


Fig. 5.11 Soybean Hand Grinder
1. Hopper 2. Screw 3. Casing 4. Rotating Metallic Grooved Plate 5. Clearance Adjustment Screw 6. Outlet 7. Gripping Screw 8. Wheel 9. Handle Dimensions in mm

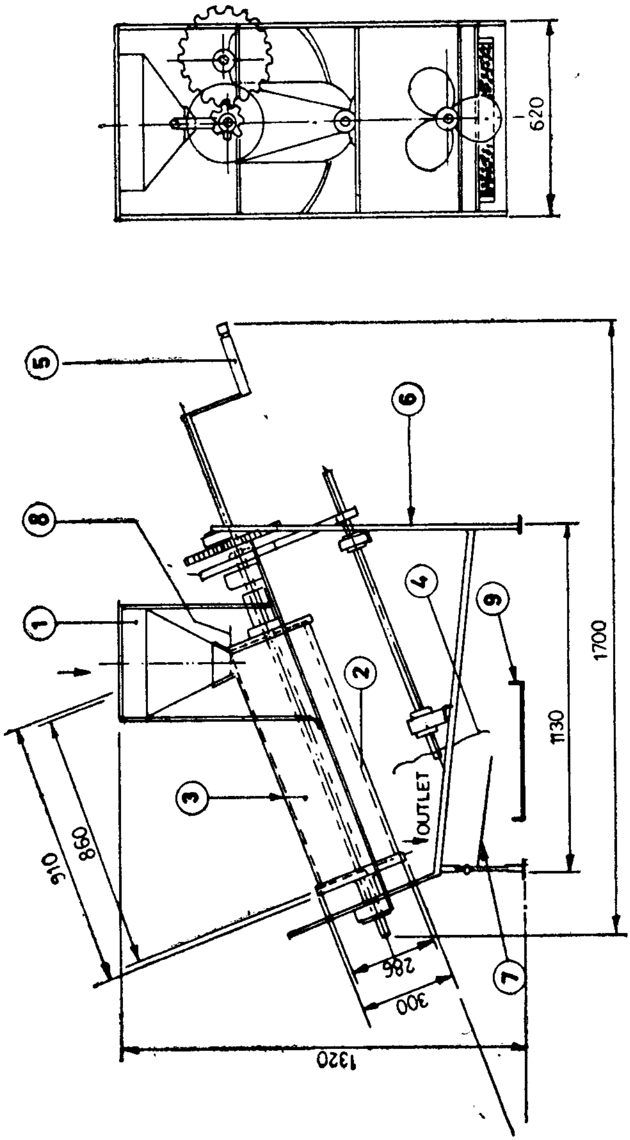


Fig. 5.12 Soybean Dehuller (Manual)

1. Hopper 2. Inner Cylinder 3. Outer Cylinder 4. Fan 5. Handle 6. Stand 7. Deflector Screen 8. Feed Adjustor 9. Dhal Collector

In addition to above, a hand operated dehuller has been developed at CFTRI, Mysore which has capacity of dehulling 40-70 kg seed/h and costs Rs. 3,500\-. CIAE, Bhopal has also developed a 0.5 hp

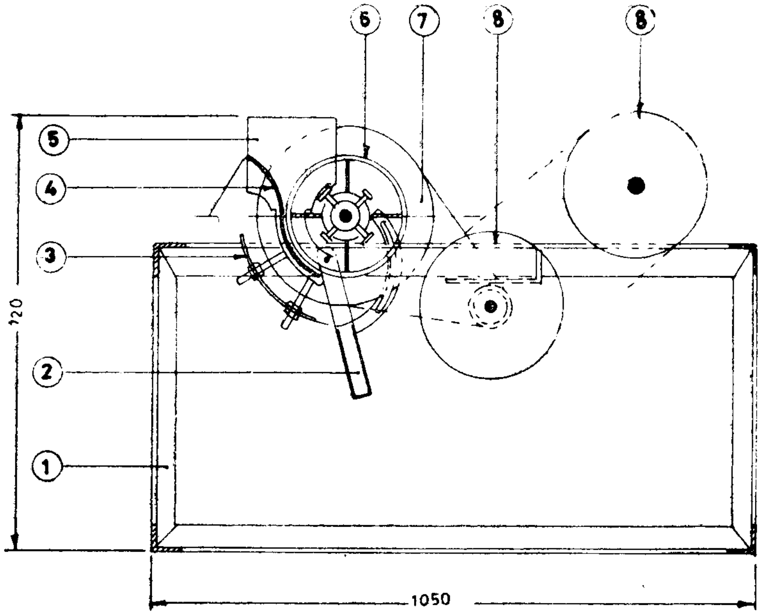


Fig. 5.13 Pulse Grain Dehuller

1. Angle Iron Frame 2. Discharge Chute 3. Support 4. Concave
5. Side Board 6. Cylinder 7. Pulley 8. Variable Speed Pulley

motor operated multiseed decorticator, basically for sunflower and safflower, which dehulls soybean with a capacity of 80 kg/h.

5.6 Blanching

Raw soybean contains some anti-nutritional factors which could be inactivated/eliminated by wet-heat treatment of the seed. This process is known as blanching and is esssential to make soybean fit for human consumption. Blanching is done by cooking soybean in boiling water for 10-15 minutes or by application of steam to wet beans. Based on these principles, two types of blanchers (Figs. 5.16 & 5.17) have been developed in India which are compared below in Table 5.6.

5.7 Milling (size-reduction)

The high oil content of soybean poses problems of choking of stone burr as well as hammer mills while preparing soybean flour

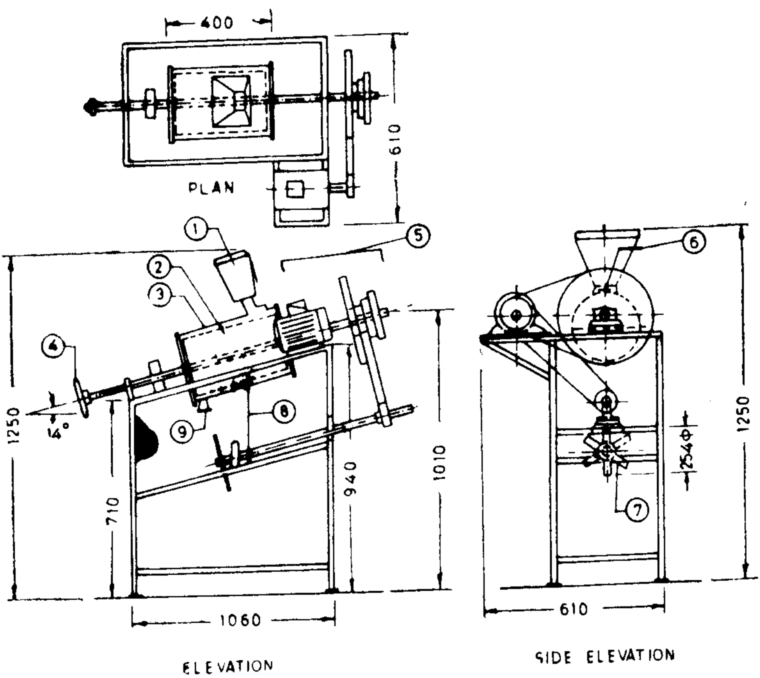


Fig. 5.14 Power operated Soybean Dehuller

1. Hopper 2. Inner Concentric Cylinder 3. Outer Concentric Cylinder 4. Clearance Setting Screw 5. Power Transmission System 6. Feed Control 7. Fan 8. Side Cover 9. Outlet

Dimensions in mm

The flour produced bv stone burr mills is used in conventional dishes whereas fine grade flour produced from hammer mills may by used for mixing in Maida for bakery uses. In additiod, soybean is sometime wet milled into paste to prepare various products such as soybadi, snacks, soy paneer, paneer, etc. For these purposes 4 various equipment namely mini multipurpose grain mill, screw type wet grinder, plate type wet grinder and DOC (Deoiled cake) grinder (Figs. 5.18–5.21) may be used. Table 5.7 gives the comparative description of the equipment.

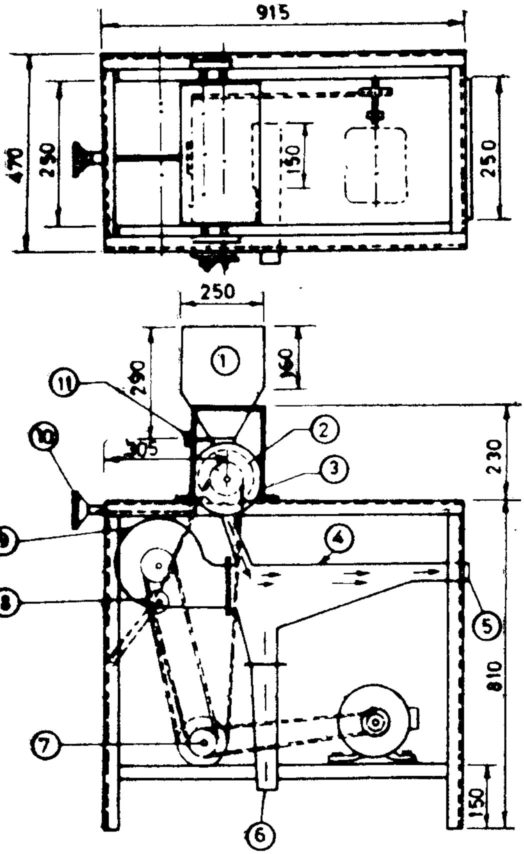


Fig. 5.15 Cylinder Concave Dehuller

1. Hopper 2. Dehusking Cylinder 3. Cylinder Housing 4. Wire Mesh 5. Husk Outlet 6. Dehulled Grain Outlet 7. Main Drive Shaft 8 Jockey Pulley 9. Blower 10. Concave Cylinder Clearance Adjusting Wheel 11. Grain Metering Plate

Dimension in mm

5 8 Flaking

For preparation of soy-flakes, CIAE, Bhopal has developed a flaking machine (Fig. 5.22). The soyflakes can be used by mixing it in cereals and vegetables in daily diet to increase protein content. The specifications and test results of the flaking machine are given below :

Type	:	Two stage, roller type
No. of rollers	:	Three (Two big and one small)
Diameter of big rollers	:	112.5 mm
Diameter of small roller	:	88 mm
Speed of rollers	:	100, 200 & 400 rpm
Capacity	:	20 kg/h
Labour requirement	:	One
Power requirement	:	1 hp
Cost of equipment	:	Rs 5,000/-
Cost of flaking	:	Rs 167/t

Table 5.5 Comparative description of different soybean dehullers

Dehuller/ developed at	Type	Capacity, kg/h	Power req.,	Labour req	Cost, Rs.	Cost of operation, Rs/t
Hand grinder (available commercially)	Plate type, low capacity	6	Manual	1	100	330.0
Manually operated dehuller/ CIAE, Bhopal	Concentric cylindrical	35	Manual	1	2000	64.0
Soybean dehuller/GBPUAT, Pant Nagar	Cylinder-concave type	300-500	2	1	2000	—
Power operated soybean dehuller/CIAE, Bhopal	Concentric cylinder	100	2	1	3000	31.0
Cylinder-concave dehuller/ IARI, New Delhi	Cylinders concave	128 140	1	1	3000	24.0

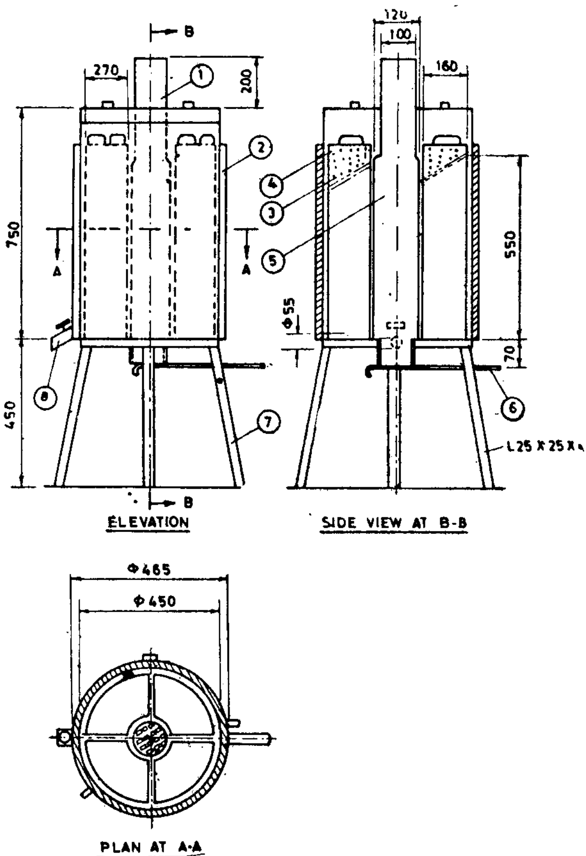


Fig. 5.16 Soybean Blanching Unit

1. Burning Cylinder 2. Outer Cylinder 3. Asbestos Rope Insulation
4. Perforated Cage 5. Burning Zone 6. Grate 7. Stand
8. Gate Valve

Dimensions in mm

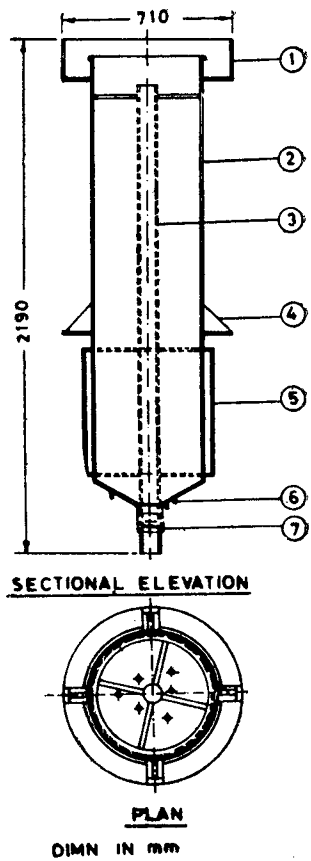


Fig. 5.17 Steam Blancher for Soybean

1. Overflow Skirt 2. Blancher Body 3. Drain Tube 4. Supporting Stand 5. Steam Jacket 6. Steam Tube Coupling 7. Gate Valve

Dimensions in mm

The soyflakes produced from above equipment have about 10mm x 7 mm x 1 mm size, 436 kg/m^3 bulk density, 199% water absorption

Table 5.6 : Comparative descriptionn of soybean blanchers

Specifications Test Results	CIAE, Blancher	Pant Nagar Blancher
Developed at	CIAE, Bhopal	GBPUAT, Pantnagar
Type	Concentri cylinde-rical batch type	Steam blancher
Capacity, kg/h	20	60
Fuel requirement, kg/h	3.5 Wood chips	Steam at the rate of 45 kg/batch at 15 kg/cm^2 presure
Labour requirement,	2	1
Cost of equipment, Rs	1,500	18,000
Cost of operation, Rs/t	380.0	—

capacity, 3.62% moisture content, 49% protein content, 22% oil content and 5.4% fibre content. Fig 5.23 presents the process flow chart for making soyflakes at rural level. The process starts with cleaning of soybean by a cleaner. The cleaned soybean is further graded so as to remove brokens in mature grain to get food quality of the end product. The dehulling of soybean is the next operation where grain splits in to two halves and the husk and germ are separated to produce clean whole soybean dal. This dal is now blanched in boiling water for 60 min, so as to reduce the urease activity below 0.5%. The blanched soybean contains about 60% moisture (wb) which is dried in a tray drier to 25-30% moisture content. The soydal at 25-30% moisture content is flaked using the above mentioned flaking machine. After flaking, the flakes are dried to 8% moisture level for safe storage.

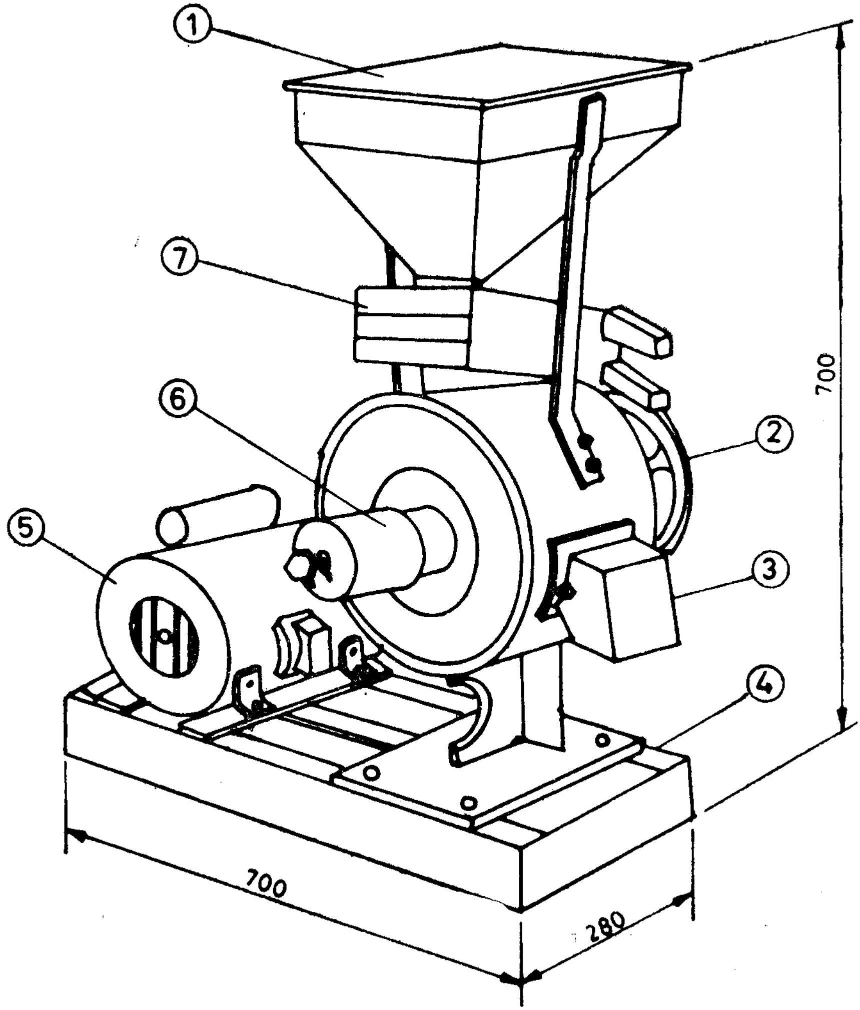
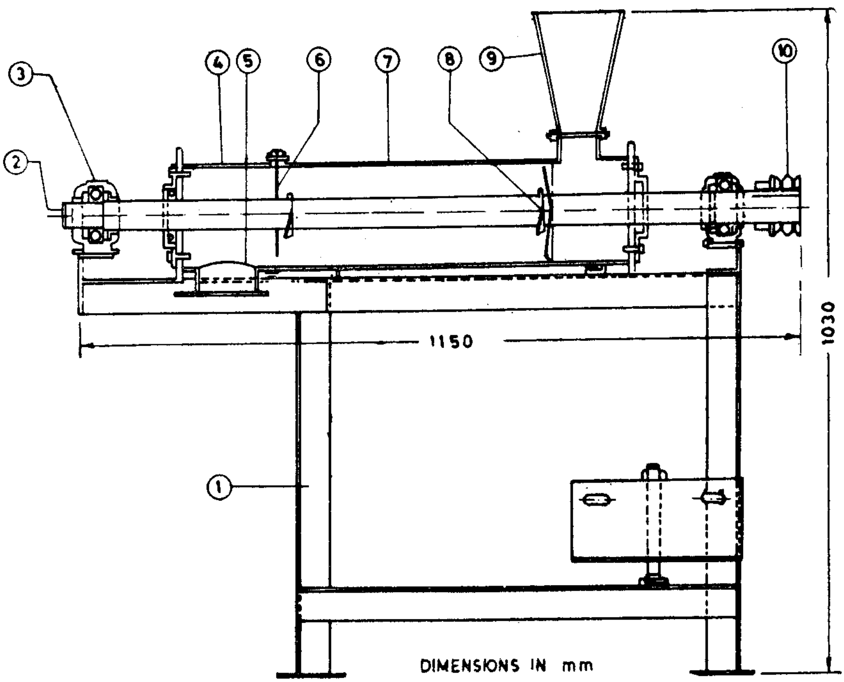


Fig. 5.18 Multipurpose Grain Mill

1. Feed Hopper 2. V Belt Pulley 3. Product Outlet 4. Platform
5. Motor 6. Clearance Variator 7. Clearance Adjustment

All Dimensions are in mm



Fin 5.19 Screw Type Wet Grinder for Soybean

1. Stand 2. Shaft 3. Bearing Assembly 4. Discharge Section 5. Discharging Mouth 6. Screen 7. Grinding Section 8. Cutting Blade 9. Hopper 10. Driving Pulley

Dimensions in mm

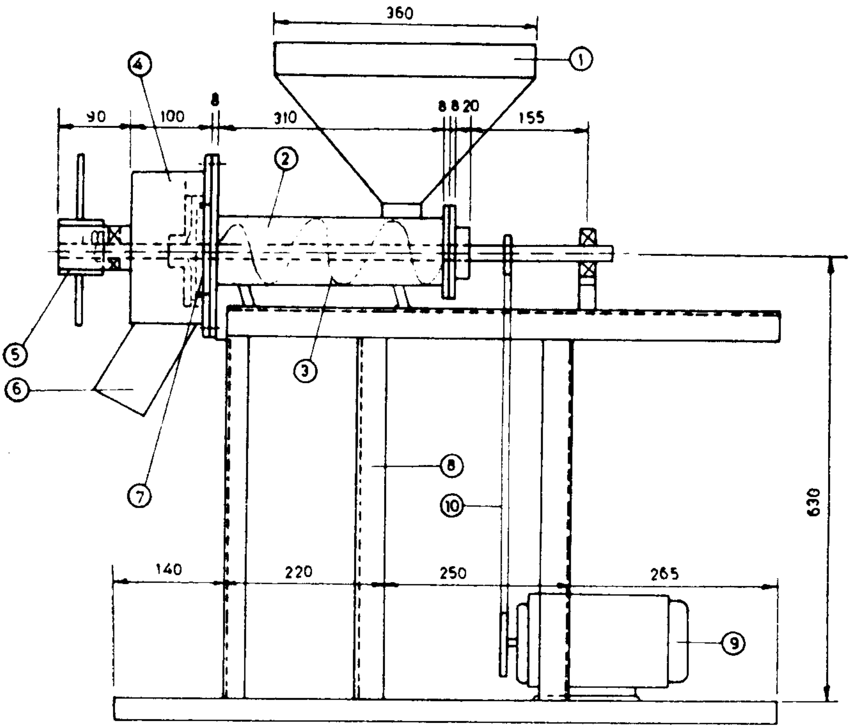


Fig 5.20 Plate Type Wet Grinder for Soybean

1. Hopper 2. Barrel 3. Screw 4. Casing 5. Clearance Mechanism 6. Outer 7. Grinding Plates 8. Frame 9. Motor 10. V Belt

Dimensions in mm

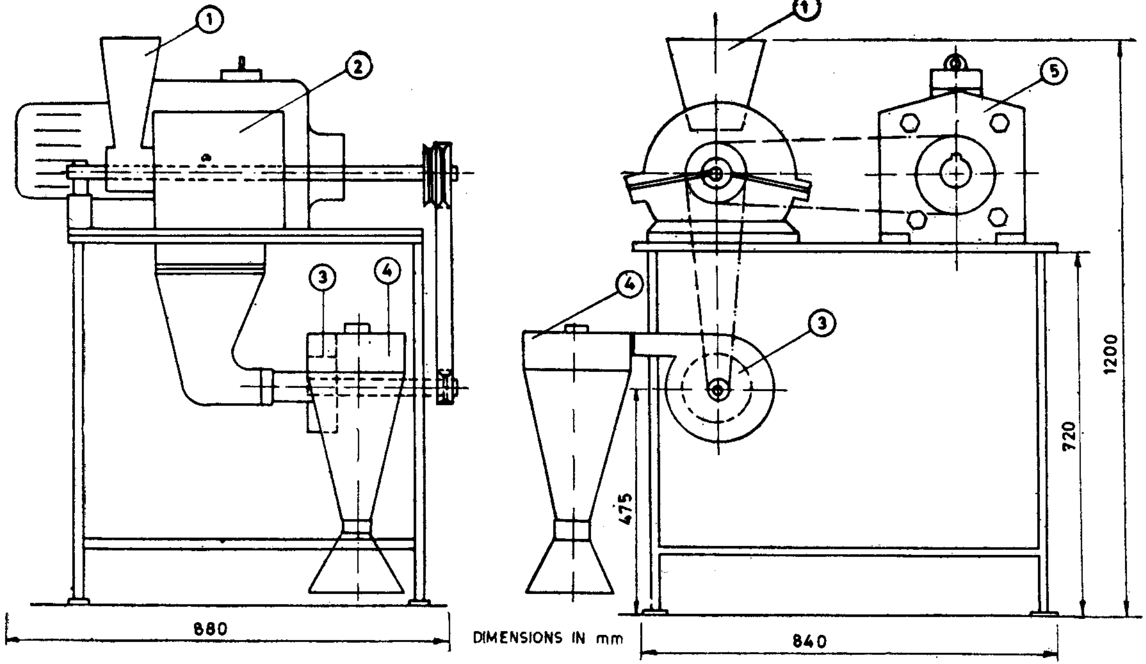


Fig. 5.21 Soybean Cake Grinder

1. Feeding Hopper 2. Pulverizer 3. Blower 4. Cyclone 5. Motor

Table 5.7 Comparative description of soybean milling equipment

Equipment/ developed at	Type	Cepacity kg/h	Power req., hpr	Labour eq.	Cost of	
					equip. Rs	operation Rs/t
Mini grain mill/CIAE, Bhopal	Vertical burr type	70 kg for splitting, 50 kg per flour making	1	1	4000	46–140
Screw type wet grinder/ GBPUAT, Pant Nagar	Continuous screw type	50	5	1	12,500	140
Plate type wet grinder/ CIAE, Bhopal	Axial feeding plate type	20	1	1	3000	124
Soybean deoided cake grinder/CIAE Bhopal	Bar type hammer mill	10–12	5	1	7000	538

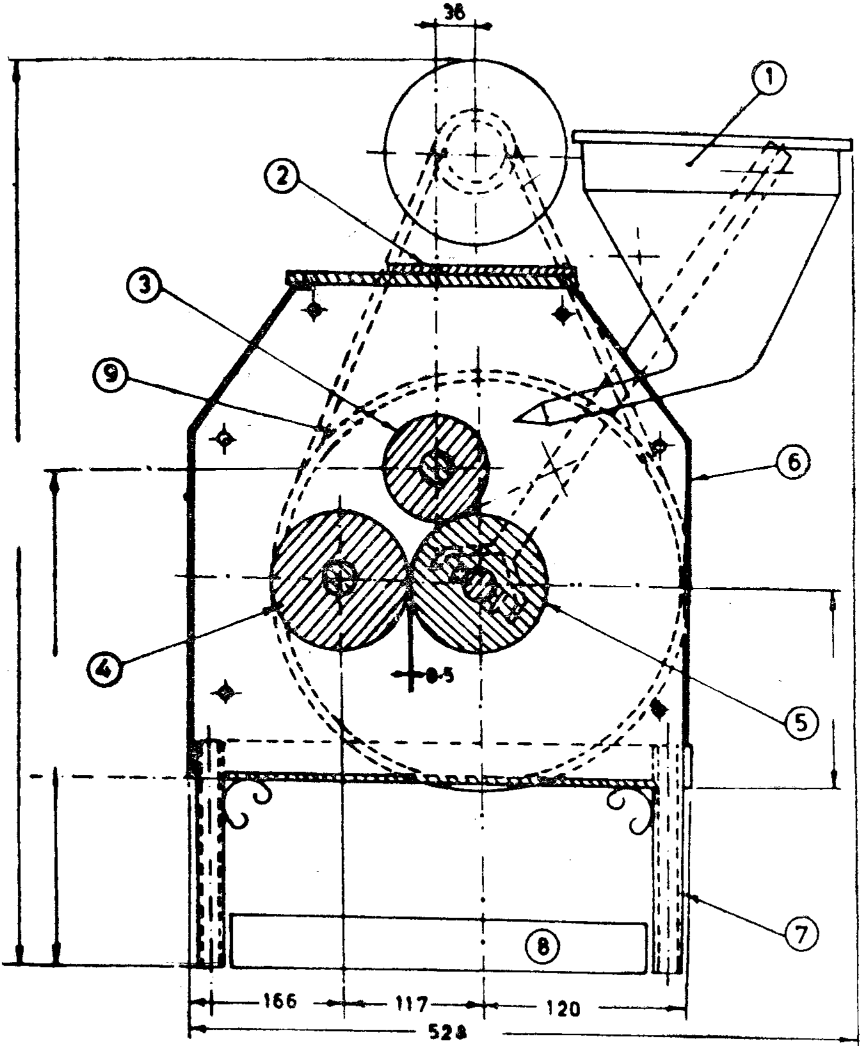


Fig. 5.22 Soybean Flaking Machine

1. Hopper 2. Base for Motor 3. Small Roller 4. BIG Roller 5. Power Roller 6. Supporting Plates 7. Stand 8. Collecting Tray 9 Pulley

All Dimensions in mm

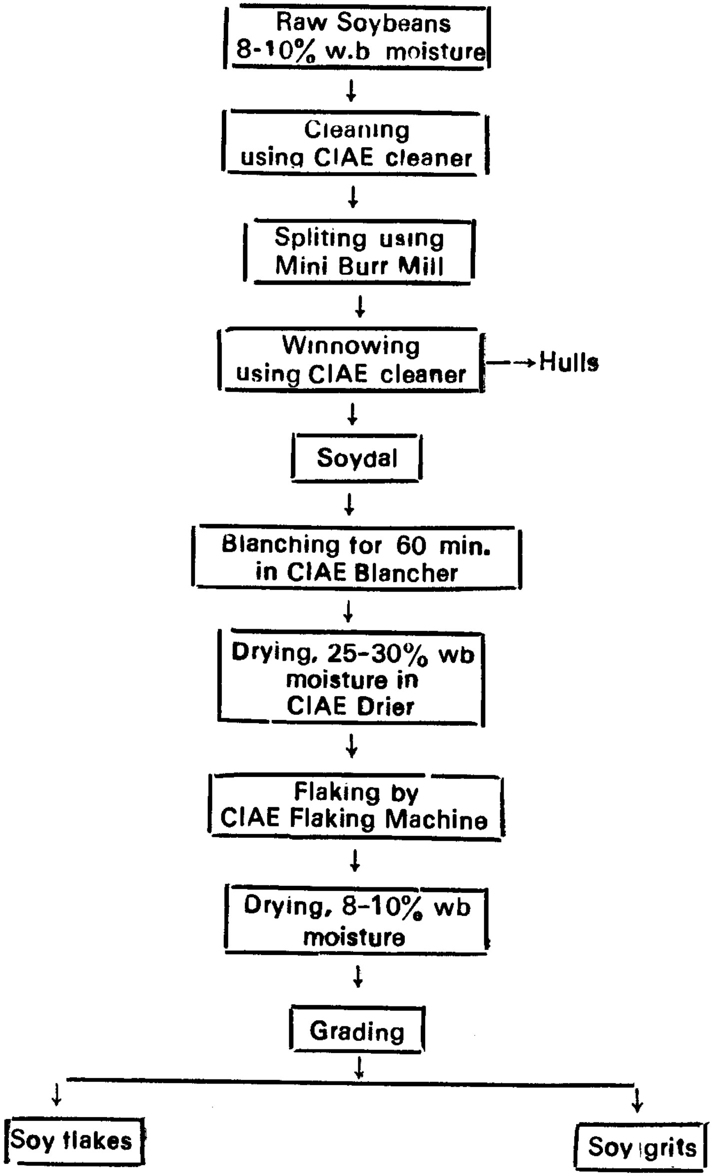


Fig. 5.23 Process Flow Chart for Making Soyflakes at Rural Level

5.9 Storage

Soybeans are very sensitive seeds. Storage temperature above 20°C has adverse effect on its germination and oil content. Insects and pests are very attractive to soybean because of its high protein and fat content.

In general, bag storage is the common practice for demostic level storage of soybean in rural areas. However, bags are found unsuitable for prolonged storage of soybean. Pusa bin is reported to be superior to mud bin, steel bin and gunny bags for this purpose. Cold storage is also reported to be safe for soybean. Polyethylene and glass containers maintain better germination percentage/viability of seeds in comparison to paper containers for 3 months storage. GBPUAT, Pantnager has reported that the loss in germination of soybean seed linearly increases with the height of drop at a rate of one percent per meter when it is dropped on cement surface thus indicating that the height of drop of soybean during grain storage should not be more than 2 meters. GBPUAT, Pantnager has also reported that germination percentage of soybean decreases with storage life and in one year's storage period, almost all the soybean varieties lose their viability completely. Loss in seed viability is more pronounced in high seed moisture as compared to low moisture seed. The germination of soybean seed is also reported to decrease significantly non-linearly with consolidation period. Viability of Bragg and Ankur varieties of soybean seed decrease with increase in temperature and 20°C temperature is reported to be safe. This indicates there is no need of specific storage structures for temperature below 20°C as well as of controlling Rh below 80% for storage of soybean.

Studies were conducted at CIAE, Bhopal to evaluate various farm level storage structures, viz. gunny bags, earthen pitchers, polyethylene lined mud bin, Hapur bin, Pusa bin and wooden bin with their capacities varying from 50 to 500 kg. It was observed that the temperature variation was more or less similar throughout the storage period of 7 months and polyethylene lined mud bin, Pusa and Hapur bins recorded lesser temperature than gunny bags, earthen pitcher and wooden bins (Fig. 5.24). The variation in mean percentage of moisture was from 8.6 to 8.8% after a period of one month in which the gunny bag, earthen pitcher and polyethylene lined mud bin had lower percentage than Pusa bin or other structures. The moisture variation in the remaining period is shown in Fig 5.25 which indicates that at the end of seven months storage in June, the Pusa bin had maximum moisture content of 9.1%. The level of insect infestation (Fig 5.26) was not very high from the beginning of the storage period in various storage structures. However, gunny bags and wooden bin recorded more infestation compared to others, Fig 5.27 shows the variation in germination percentage of soybean seeds in these structures.

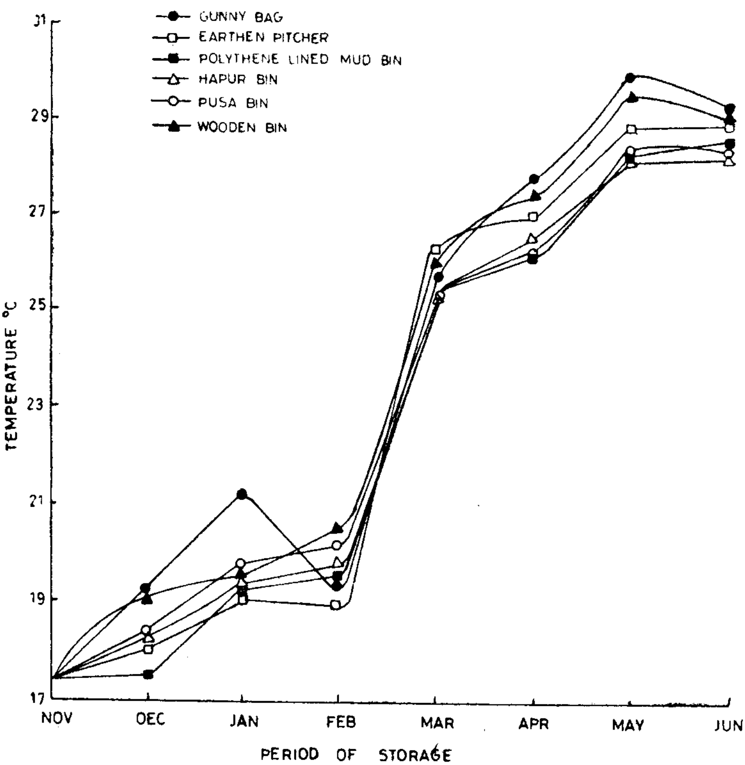


Fig. 5.24 Temperature variation in Soybean Seed Stored in Different Storage Structures

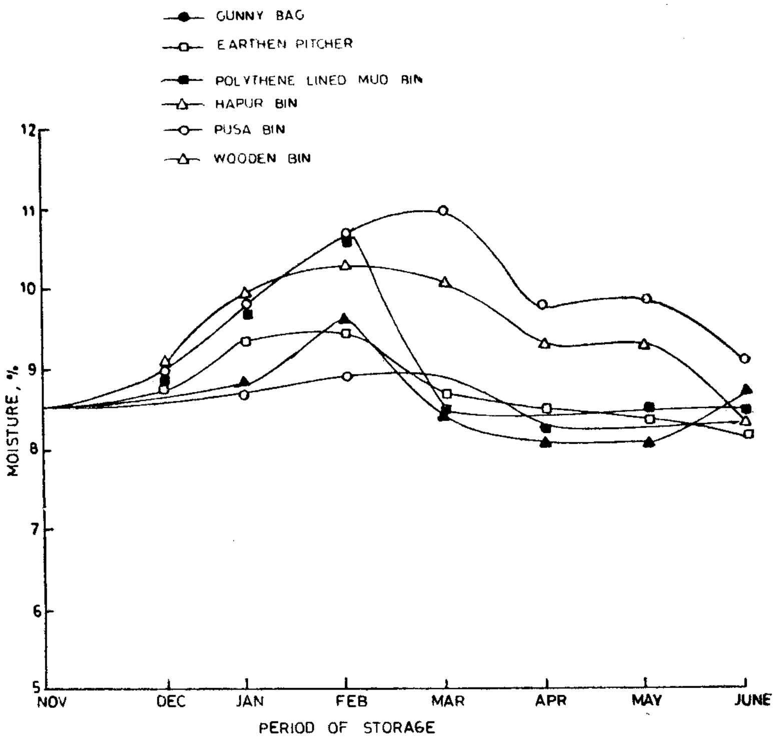


Fig. 5.25 Moisture Variation in Soybean Seeds Stored in Diffetent Storage Structures

The above studies indicate that soybean seed could be stored successfully at farm level in metallic bins for 4-8 months, if it is properly dried (8-9% moisture level), treated with a suitable fungicide (say Thyram 3g/kg) and kept in a reasonably air tight storage structure, placed in the coolest part of building where grain temperature may not exceed 35°C. The viability of seed under the conditions could be maintained above 70%. In this reference results of the experiment conducted by Toole and Toole (1946) may be of interest which has established that soybean with 9.4% moisture content (60% RH) could be stored for a period of 10 years, 5 years and one year respectively under 10°C, 20°C and 30°C temperature whereas the seed with 13 9% moisture content (about 80% RH) could only live for a period of 5 years

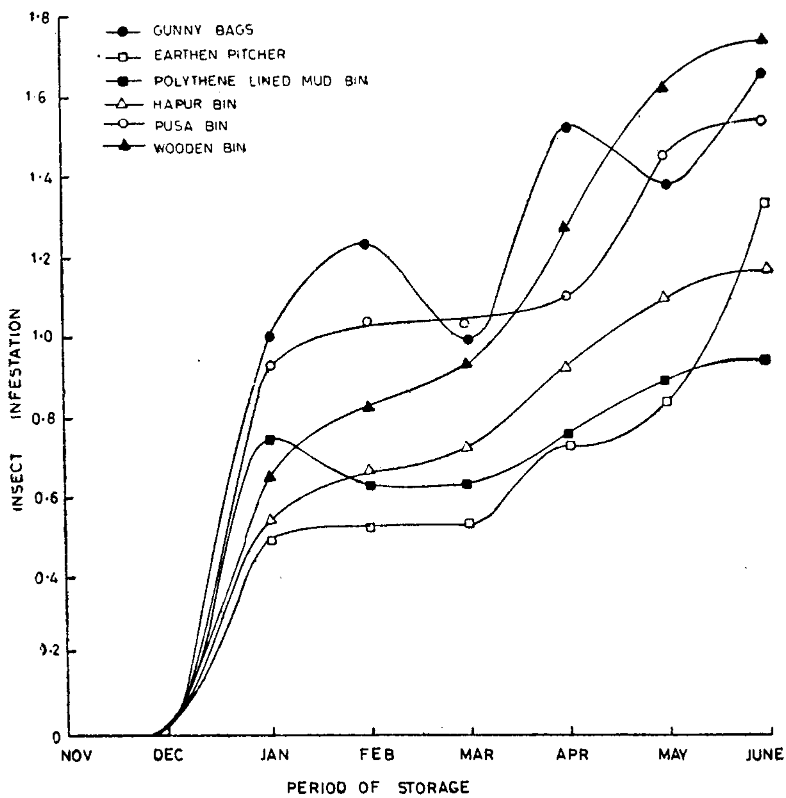


Fig. 5.26 Insect Infestation in Soybeans Stored in Different Storage structures

and one year under 10°C and 20°C temperatures. Seed with 13.9% moisture content lost the germinability within 6 months period at 30°C temperature as shown in Table 5.8.

5.10 Oil Extraction

Soybean oil is conventionally recovered by solvent extraction. Mechanical deoiling of soybean using hydraulic press and/or screw press has not been commercially practisced either independently or as pre-press to solvent extraction because of low oil content of soybean and due to inability of mechanical process to remove the last about

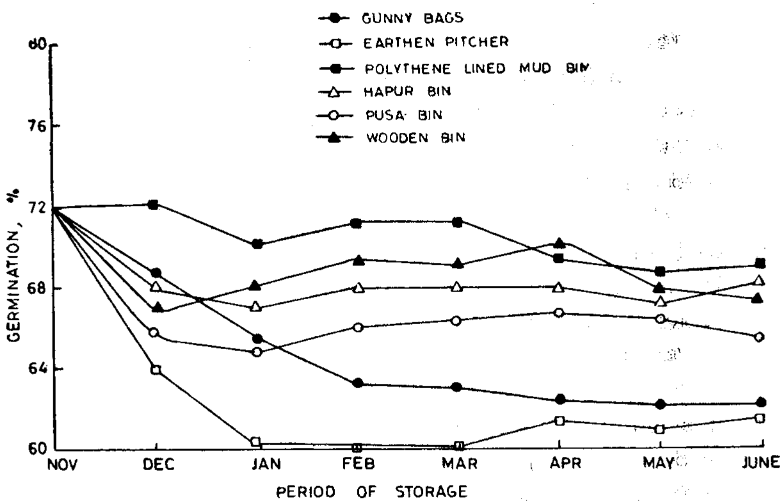


Fig. 5.27 Germination of Soybean Seeds Stored in Different Storage Structures

Table 5.8 : Effect of seed moisture content and temperature on germination of soybean seed during storage

Moisture Content. %	Temperature, °C	Storage period, years 0.5	1	2	3	4	5	10
		Germination, %						
9.4	10	93	95	98	93	99	92	94
	20	97	99	96	94	89	90	0
	30	96	87	0	—	—	—	—
13.9	10	95	98	96	92	88	49	0
	20	98	93	0	—	—	—	—
	30	0	—	—	—	—	—	—

Source : Singh and Singh, 1988

10% of oil from seeds. Soybean are conventionally subjected to direct solvent extraction which recovers about 99% of the oil. However, there has been evidence as early as 1933 that mechanical deoiling of soybean was possible if the seeds are properly prepared. Here it may be noted that mechanical deoiling of whole or half soybeans is not possible due to impervious nature of oil cells (Othmer and Agrawal, 1955) and the cell walls must be broken. Though cleaning and cracking of soybean were reported to be sufficient preparatory operations (Steinbock, 1948), flaking was considered essential (Othmer and Agrwall 1955) to remove oil from impervious cells of soybeans. Galloway (1976) reported that soybeans should be cracked into quarters and eighths and be dehulled before being flaked and conditioned. The dehulled, rolled, steam conditioned flakes were found to result in maximum oil yield of 85 71% (Khan and Hanna, 1984). Flaking with hulls by extrusion at 140°C resulted in an oil yield of 66.6% while ground soybeans with hulls gave the lowest yield of 57.7% Smith and Kray bill (1933) have reported on oil yield of as high as 82% from unhulled and ground soybean which was dried in vaccum oven at 48 50°C. Nelson (1986) has reported that extruding and pouring the hot extrudate in the expeller results in 70-80% oil recovery and a blond, light golden edible cake.

The oil yield from soybean, like other oilseeds, is affected by pressing temperature, pressure, time and moisture content, the temperature-moisture content interaction being most significant. The oilyield in general increases with increasing temperature and decreasing moisture content. Smith and Kraybill (1933) observed this effect of temperature upto 100°C and of moisture content over a range of 0-8% on oil yield from unhulled, ground and vacuum dried soybean and so did Khan and Hanna (1984) for unhulled ground soybean over a temperature range of 20-60°C and a moisture content range of 7.5-12% Their data does not exclude the possiblity of increased oil yields above the temperature of 60°C and below the moisture content of 7.5%, although Williams and Rathod (1974) also reported best oil yields from soybeans at 7-8% moisture content. They obtained oil yields of over 80% in a triple pass expelling process using a modified screw press developed for the production of soy-flour in India and a cake of edible grade.

In case of flaked and cooked/conditioned soybean, however, while the temperature affects oil yield the same way, existance of an optimum moisture content has been indicated for best oil yield. Koo (1942) has reported an optimum moisture content of 10% over a temperature range of 30–75°C for hulled, decorticated, ground, cooked and steamed soybean. Khan and Hanna (1984) have also found an optimum moisture content of 9.5–10% for best oil yields from unhulled, cooked and flaked soybean. In case of hulled, flaked and steam conditioned soybean also the best oil yield of 85.7% was obtained at the highest temperature of 60°C investigated and 9.5–10% moisture content by Khan and Hanna (1984), although the effect of moisture content was not investigated in this case. This data also does not exclude the possibility of still increased oil yields at temperatures exceeding 60°C.

In general the oil yield increases with increase in pressing time to certain limit and with increasing pressing pressure within the range between oil point and extrusion point of prepared meal. Koo (1942) reported using pressures of 13.8–27.6 MPa over 1-5h pressing time in a laboratory Carver hydraulic press and observed oil yield to vary directly with the square root of pressing pressure. The effect of pressing time was relatively less pronounced, oil yields varying directly with the sixth root of pressing time. Khan and Hanna (1984) investigated pressing pressures of 35 and 45 MPa for 5 and 6 min. pressing times in a specially developed compression test cell resembling a compression permeability cell. They indicated that lower pressures were not enough to express oil from prepared soybean meal whereas higher pressures extruded the sample. Similarly, shorter and longer pressing durations did not significantly affect the resultant oil yield. This data reflects an increase of 2–3% in oil yield by increasing pressing time over the range investigated while the effect of pressure is marginal.

Studies have been conducted at CIAE, Bhopal to use screw press type expeller for oil extraction from soybean, by first converting whole soybean into split pulse (dal). Cleaned soydal, after separation of hulls and other impurities is thoroughly soaked with water before oil extraction. Maximum oil recovery of 71.5% was achieved at 9% moisture content with minimum energy consumption. For this Mini-40 screw press (Fig. 5.28) was used.

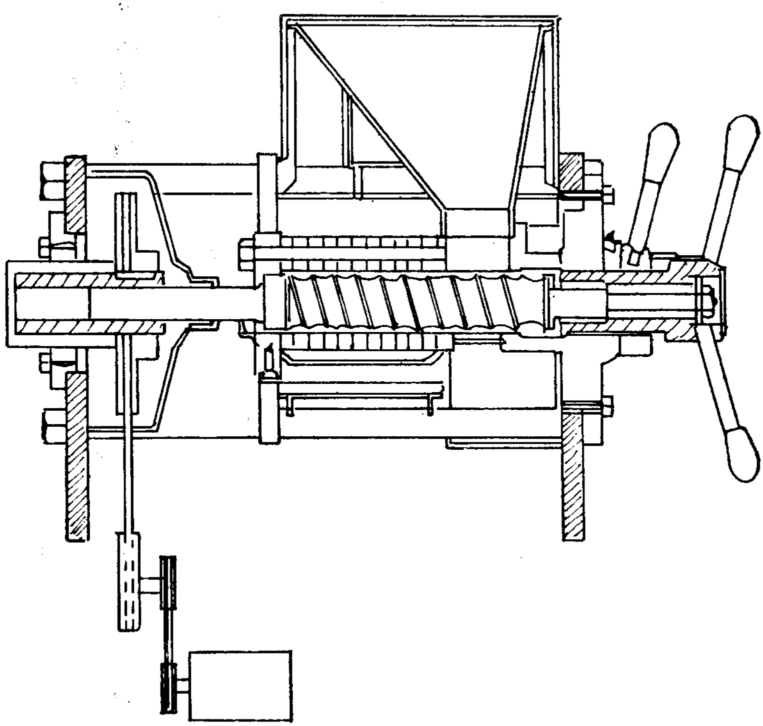


Fig. 5.28 Sectional View ofMini-40 Expeller

Soydal of JS-7244 variety was soaked in water for one hour at room temperature and later dried to various moisture levels ranging between 5 to 11% (w. b.). Table 5.9 presents the values of oil recovery, energy consumption and temperature rise. The samples with 9% moisture content yielded maximum 71.5% oil. It may be due to the fact that though at lower moisture content (below 9%) the brittleness of dal is more but the rupturing of oil cell walls is not sufficient. In case of higher moisture levels (above 9%), the oil recovery goes down mainly because of the plasticizing effect of the soy-meal in the screw barrel assembly which causes poor compression. In order to further improve the oil recovery, soydal as well as whole soybeans were soaked in boiling water for half an hour and then dried to about 5, 7, 9 and 11% moisture content and expressed. Average values of three replications are presented in Tables 5.10 and 5.11. The oil recovery of 69.10, 84.06, 72.40 and 64.2%, corrosponding to above moisture levels were found. Best oil recovery of 84.06% was obtained from soydal containing 7% moisture level. It is interesting to note tbat in case of whole soybean boiled samples, the oil recovery further increased yielding 74%, 84.65%, 74.68% and 71.78% oil yields respectively corresponding to above moisture levels This could happen mainly due to (a) the wet heat supplied through such boiling treatment helped in better rupture of the cell walls and globules which helped in easy oozing out of the hull, (b) hulls acting as roughness material provide better frictional forces and compression during the process of expression and (c) rough but small particles of the hulls create better porous media and allow relatively lesser resistance to outflow of oil Though the oil yield in this case was slightly better, the cake quality was unfit for human consumption due to hull content. Thus considering the importance of the edible quality cake, half an hour boiling treatment of soydal followed by drying to about 7% moisture content may be recommended for mechanical deoling of soydal. With hope to further improve the oil recovery, soydal samples were given the steam treatment for 5, 7.5, 12.5, 17.5 and 20 minutes followed by flaking prior to expression in mini-40 screw press. The oil recovery obtained in the total of 4 passes corresponding to the steam treated samples in order were 71.25, 70.43, 82.62, 64.25, 82.9 and 11% respectively (Table 5.12). Though, there was not much difference in the oil recovery when compared to the previous treatment, the expression of soy flakes did not present problems in the mini-40 press and operation was quite smooth.

Studies are on-going for extrusion-expelling of soybean The critical factor in the extrusion-expelling technology is to obtain a semifluid extrudate by appropriate extrusion conditions and to expell without any lapse of time. For soybean, the dry extrusion coupled with mechanical expelling for getting oil and cake suitable for human

Table 5.9 : Performance of Mini-40 Screw press (Oil expeller) with soybean dal

Varisty : JS 7244
Treatment : 1 hour soaking in tap water

Feed Qnty.	M.C.	Passes	Cle-arance	Time taken		Total oil with particles in suspension	Foots after 24 h	Net oil yield	Energy consumed	Oil recovery (total oil basis)
kg	%		mm	Min.	Sec.	cc	cc	cc	kWh	%
3	5.5	I	1.00	26	19	236	120	116		
		II	0.75	18	10	144	81	63		
		III	0.50	16	17	123	31	92		
		IV	0.50	17	7	56	36	20	0.616	49.59
3	7	I	1.00	20	6	120	41	79		
		II	0.75	19	21	208	125	83		
		III	0.50	17	20	240	125	115		
		IV	0.50	16	11	55	15	40	0.594	54.02
3	9	I	1.00	7	2	121.2	13.2	107.9		
		II	0.75	18	3	263	25.1	237.9		
		III	0.50	19	2	96	14.8	81.2		
		IV	0.50	13	35	30.8	8.6	22.2	0.537	71.55
3	11	I	1.00	25	10	57	7	50		
		II	0.75	19	16	245	114	131		
		III	0.50	19	2	152	5	147		
		IV	0.50	17	15	26	2	24	0.490	60.00

Table 5.10 : Performance of Mini 40 Screw Press Oil Expeller with Soybean dal

Variety : JS 7244

Treatment : 30 mts boiling in water

Feed Quantity	Approx. M.C. of prepared sample	Passes	Clearance	Time of crushing		Total oil with particles in suspension	Foots after 24 h	Net oil yield	Temp. at oil outlet	Energy consumed	Oil recovery (total oil basis)
kg	% wb.		mm	min.	sec.	cc	cc	cc	°C	kWh/kg	%
2	5	I	1.0	10	4	90.00	18.33	71.67	117.33		
		II	0.4	11	56	180.00	61.67	118.33	122.67		
		III	0.4	10	24	91.50	21.33	70.17	136.67		
		IV	0.4	9	56	20.00	10.00	10.00	140.00	0.578	69 10
2	7	I	1.0	12	44	176.67	25.67	151.00	117.67		
		II	0 4	13	62	195.33	37 67	157.66	126.33		
		III	0.4	11	50	27.67	7.67	20.00	135.67	0.369	84.06
2	9	I	1.0	9	3	95.00	19.00	76.00	120.00		
		II	0.4	8	2	136.00	26.33	109.67	128.33		
		III	0.4	10	44	110.00	12.60	97.60	133.33	0.440	72.40
2	11	I	1.0	10	1	89.33	30.67	58.66	113.33		
		II	0.4	12	24	175.33	60.00	115.66	121.33		
		III	0.4	10	26	88.67	23.00	65.67	132.00		
		IV	0.4	10	35	22.33	11.00	11.37	135.00	0.443	64.2

Table 5.11 : Performance of Mini 40 Screw Press (Oil expeller) with whole soybean

Variety : JS 7244
Treatment : 30 mts boiling in water

Feed Qnty.	M.C.	Passes	Clearance	Time taken		Total oil with particles in suspension	Foots after 24 hrs.	Net oil yield	Temp. at oil outlet	Energy consumed	Oil recovery (total oil basis)
kg	%		mm	Min.	Sec.	cc	cc	cc	°C	kWh/kg	%
2	5	I	1.0	9	9	135.00	35.33	99.67	110.67		
		II	0.4	9	22	192.67	45.67	147.00	117.67		
		III	0.4	9	94	61.00	18.33	42.67	133.33	0.545	74
	7	I	1.0	10	17	162.67	35.67	127.00	112.33		
		II	0.4	10	21	234.33	57.00	177.33	116.67		
		III	0.4	10	19	34.67	08 00	26.67	125.00	0.503	84.65
	9	I	1.0	11	26	150.67	42.33	108.34	113.33		
		II	0.4	10	15	216.00	53.00	163.00	119.00		
		III	0.4	13	35	30.00	9.33	20.67	128.33	0.486	74.68
	11	I	1.0	11	20	114.00	44.33	69.67	115.67		
		II	0.4	12	02	262.33	71.33	121.00	126.33		
		III	0.4	10	06	52.00	32.00	20.00	133.67	0.397	71.78

Table 5.12 : Performance of Mini 40 Screw press with soydal

Variety : JS 7244
Treatment : Steaming followed by flaking

Sl. No.	Steaming duration min.	Passes	Clearance mm	Cummulative oil recovery %	Overall recovery %
1.	20.0	I	1.0	7.50	
		II	0.4	37.50	
		III	0.4	70.50	
		IV	0.4	81.00	81.00
2.	17.5	I	1.0	7.50	
		II	0.4	50.25	
		III	0.4	72.00	
		IV	0.4	82.90	82.90
3.	15.0	I	1.0	7.50	
		II	0.4	37.50	
		III	0.4	56.00	
		IV	0.4	64.25	64.25
4.	12.5	I	1.0	5.70	
		II	0.4	51.34	
		III	0.4	72.98	
		IV	0.4	82.62	82.62
5.	7.5	I	1.0	4.27	
		II	0.4	44.44	
		III	0.4	64.44	
		IV	0.4	70.43	70.43
6.	5	I	1.0	10.00	
		II	0.4	49.00	
		III	0.4	65.00	
		IV	0.4	71.25	71.25

consumption was studied in the United States (Nelson et. al. 1987). Singh (1986) also conducted some experiments on soybean and found this technology as promising. The results of the study revealed that high quality oil and cake could be produced by application of extrusion prior to expelling. An oil recovery of above 70% in soybean was obtained in a single pass expelling of extrudate using a pilot plant expeller. The process flow chart is presented in Fig 5 29. The process of high temperature-short time extrusion cooking eliminates use of various other pretreatments which otherwise were unavoidable to expelling. It is reported that extrusion-expelled oil is comparable to refined and deodorized soybean oil as per NSPA specifications.

5.11 Soy-Products Production

A wide range of soy-products like soy-flour, concentrates, isolates, soy-milk, fermented products, imitation dairy products etc. are produced for which processes and equipment have been developed as described below.

(i) Defatted and full fat soy flour

Soy flour is the basic material for most of other soybased products. The standard process for producing defatted soyflour for human consumption consists of cleaning, cracking, drying, conditioning, flaking and slovent extraction under optimum conditions of time, temperature and moisture for ensuring a product of high biological value. Fig. 5.30 presents the process flow diagram of this process. In producing ful fat soyflour, clean and dehulled beans are first treated with live steam to deodorize and debitter and then the beans are dried to less than 5% moisture, passed through cracking rolls and then ground to pass through a 200 mesh screen.

Ali et. al have reported the development of an improved immersion cooking process for production of full fat soyflour at rural level utilising house hold equipment. The process consists of dehulling, soaking/steaping/blanching in 1% $NaHCO_3$ (W/μ) at room temperature for 4 hours, immresion cooking in boiling water for 20 minutes, drying and milling. From 10 kg of raw bean about 7.5 kg flour is obtained. Table 5.13 presents the chemical composition of full fat soy flour thus produced.

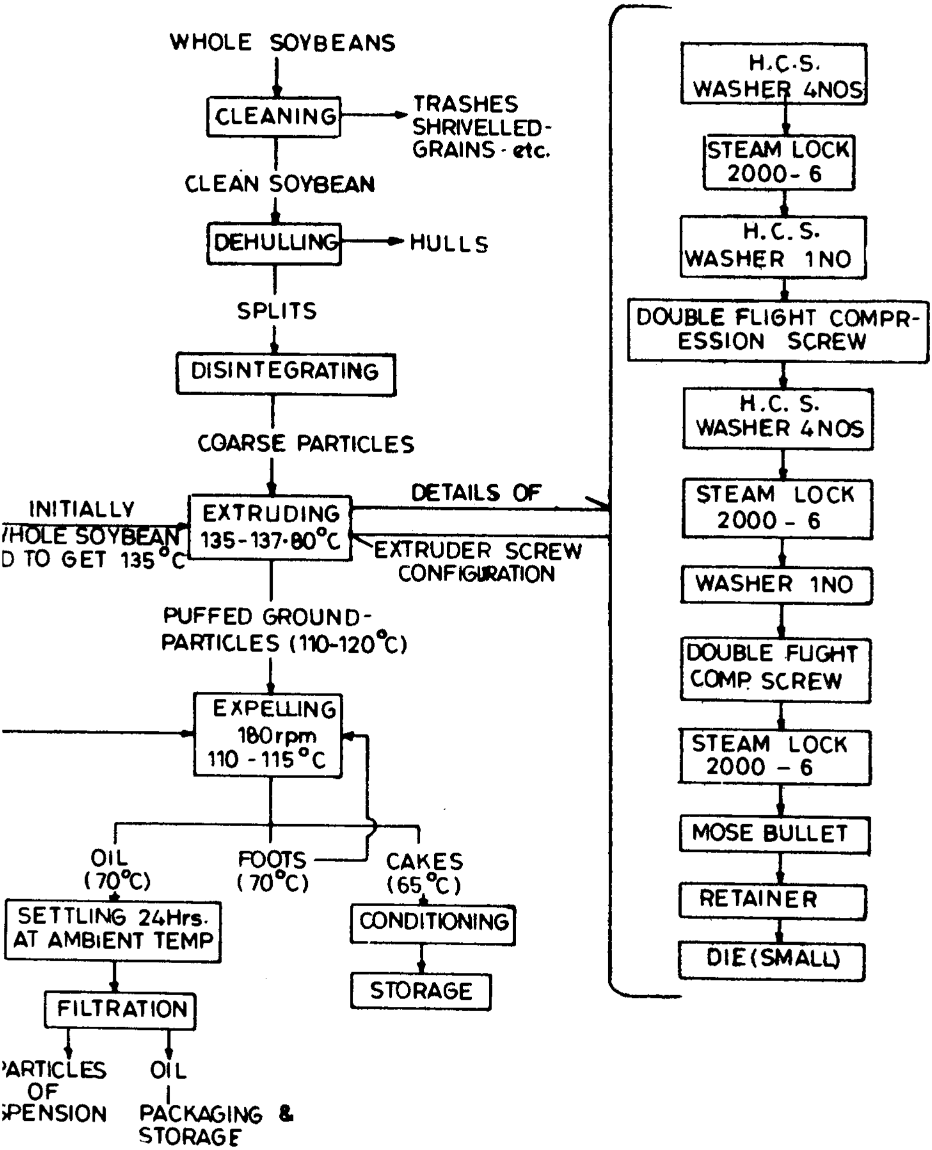


Fig. 5.29 Process Flow Chart of Extrusion Expelling of Soybean and Screw Configuration of Extruder

Whole Soybean
↓
Cleaning
↓
Drying and cooling to 9% moisture
↓
Cracking
↓
Dehulling
↓
Conditioning
↓
Flaking
↓

↓	↓
Toasting	Solvent extraction
↓	↓
Grinding	Desolventizing-toasting
↓	↓
Full fat soy flour	Defatted soy flour

Fig. 5.30 Process Flow Chart for Production of Full Fat and Defatted Soyflour

Table 5 13 : Chemical composition of fullfat soyflour.

Characteristics	Values
Moisture, % (wb)	8.0
Protein, % (Nx6.25)	40.0
Oil, %	20.0
Urease activity, change in PH units	0.0–0.1
Water eabsorption isotherm, %	206
Available lysine, % protein	6.0–6.5
Protein efficiency ratio	2.0 (2.5 casein)
Nitrogen solubility index, %	40.0
Microbial Load	
Bacterial (nos)	50.000
Fungal (nos)	NIL

Source : Gandhi et. al. 1988

(ii) Soy-protein concentrates ane isolates

Soy-protein concentrates are produced from defatted flakes or flour by immobilizing the major protein component during separation of the low molecular weight carbohydrates, mineral matters and other major constituents as presented in Fig. 5.31. The soy protein concentrates contain not less than 70% protein.

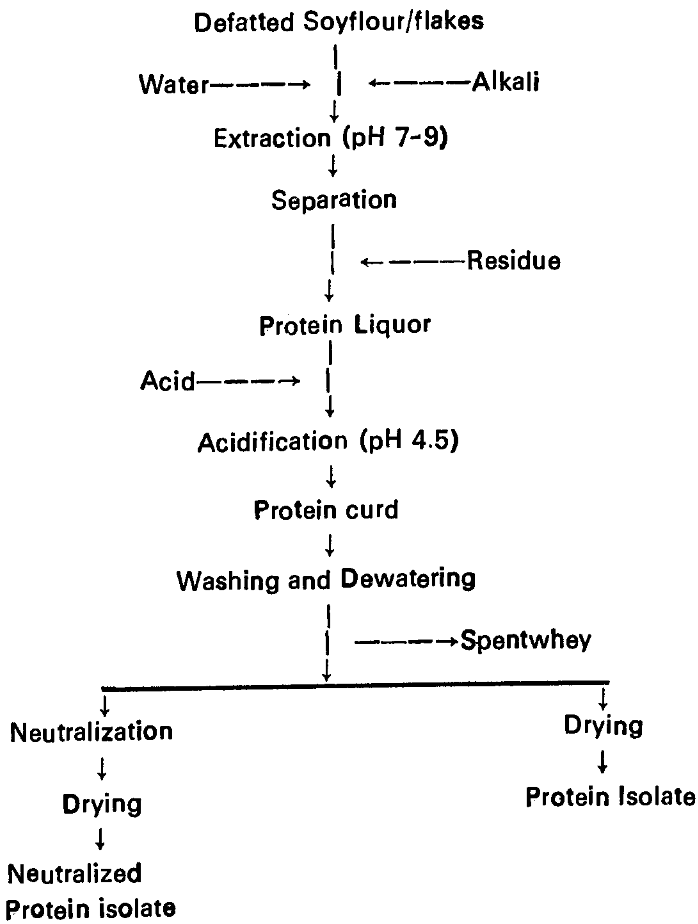


Fig. 5 31 Process Flow Chart for Production of Soy-Protein Isolates.

Soy protein isolate is prepared from defatted soyflour or flakes by extracting the proteins with an aqueous medium which may vary in PH from near neutrality to an alkaline PH. The aqueous extract is separated from the fibrous residue by centrifugation. The pH of the clerified extract is then adjusted to about 4.5 with food grade acid to precipitate the proteins. The protein curd is concentrated and washed with water. The concentrated protein can be dried as such or neutralized with food grade alkali and dried. Fig. 5.32 presents the flow chart for production of soy-protein concentrates.

Defated soyflour/flakes
↓ ← Water
Dispersion
↓ ← Acid
Precipitate
↓
Centrifugation/filteration
↓ → Whey
Protein curd
↓
Washing and dewatering
↓
Soy-protein concentrate
↓
Spray Drying
↓
Dried soy-protein concentrate

Fig. 5.32 Process Flow Chart for Production of Soy-Protein Concentrates

(iii) Soy Milk and Paneer

There are several processes for producing soy milk, all of which aim at heat treating the soybeans to inactivate trypsin inhibitors and lipoxygenase, tenderization of beans and reducing them to colloidal state to get a smooth mouthfeel. Out of several methods one is presented in Fig. 5.33.

Whole Soybean
↓
Cleaning
↓

↓	↓
Soaking (8h)	Autoclave (100°C, 2.5 min)
↓	↓
Blanching (30 min,)	Drying
↓	↓
Hulls ← Plumules — Dehulling	Dehulling
↓	↓
Cotyledons	Overnight soaking
↓	↓
Grinding	Blanching (100°C, 45 min.)
↓	↓
Homogenizing	Grinding
↓	↓
Heating (93°C)	Homogenising
↓	↓
Cooling	Spray drying
↓	↓
Soy milk	Dry soy milk powder

Fig. 5.33 Process Flow Chart for Production of Soy Milk

Coagulation of soy milk yields a white, soft gelatinous mass which has bland taste and unique body and texture resembling paneer obtained from milk in appearence as well as physico-chemical characteristics. Vizaylakshmi and Vaidahi (1982) have prepared acceptable products from coagulum obtained by the precipitation of soymilk or its combination with other milk. Naseem et. al (1986) have standardized processing param eters for preparing soy-paneer which include lavel of soydal to water for extraction, total solids content in soymilk, coagulation temperature and concentration of coagulant. Maximum extraction of total solids (55%) and proteins (62.7%) was obtained when dal to water ratio was 1:10. Soy Milk (6% of total solids) on coagulation at 75°C gives maximum yield of soy-paneer. Citric acid as coagulant gives the maximum yield with high content of total solids and protein in the product compared to tarteric, lactic and gluconic acid. Soy-paneer prepared by the use of citric acid has 74% moisture, 15.5% protein and 3.9% fat. The product possesses fragile texture.

(iv) Extruded Products

Extrusion processing of soybean produces several products such as soy-cereal based weaning food, texturized soy products etc. These products have good flavour, oxidative stability and high nutritive value. Fig. 5.34 presents the flow process chart of a typical extruder.

Whole Soybean
↓
Cracking
↓
Dehulling
↓
Flaking
↓
Pre conditioning
↓
High speed mixing
↓
Extruding
↓
Drying
↓
Milling
↓
Product

Fig. 5.34 Process Flow Chart of Typical Soy-Extruder

Following equipment have been developed for production/preparation of different products from soybean,

(a) Low Cost Single Screw Forming Extruder

This equipment (Fig. 5.35) has been developed to extrude soy blend cereal dough into strands for preparation of soyfortified snacks/

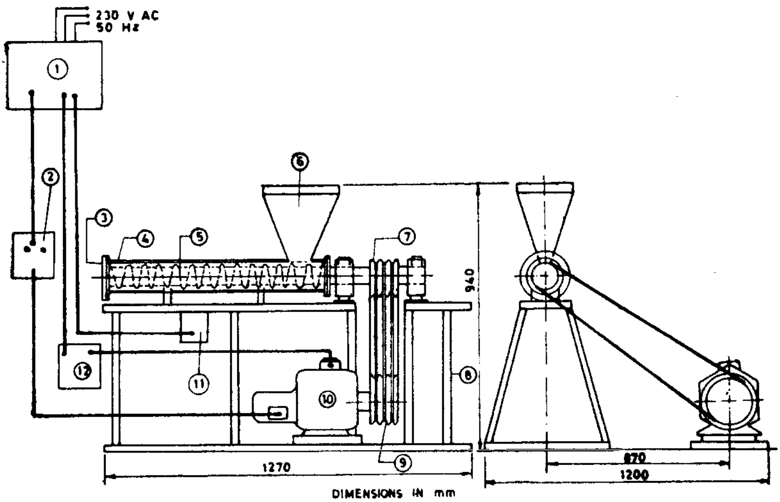


Fig. 5 35 Low Cost Single Screw Extruder

1. Mains 2. Starter 3. Outlet 4. Barrel 5. Screw Hopper 6. Feed Hopper 7. 100 ϕ V Pulley 8. Frame 9. 130 ϕ V Pulley 10. 7.5 H. P. Motor 11. Thermostat 12. Speed Regulator

Dimensions in mm

flakes. The extruder consists of a barrel, variable depth screw, thrust bearing and 7.5 hp electrict motor. A 1000 W rope heater is covered on the barrel to raise its temperature. A hopper is provided to feed the dough at suction zone of the screw and outlet a 6 hole die plate is provided to collect the extruded strands. Due to compression and shear, while conveying the material from suction to compression zone, the temperature rise takes place in the range of 40 to 70°C. The extrudate, after cutting into small pieces can be flaked or fried as such for consumption as snack after deep frying. The technical details of the equipment are as given below :

Type	:	Single screw, forming type
Developed at	:	C. I. A. E., Bhopal
Specifications;		
Effective length of screw	:	750 mm
Diameter of barrel	:	75 mm
Compression ratio	:	3 : 1
Helix angle	:	11°
Clearence between barrel and screw	:	2 mm
Power required		7.5 hp, 3 phase. AC motor
Speed of screw	:	500 rpm
Test results;		
Capacity	:	25 Kg/h
Moisture content limitation	:	above 2.5% (w. b.)
Puffing index	:	1.2
Temperature of extrudate	:	73°C full fat soyflour, 95°C soy cereal blends
Labour required	:	Two
Cost of equipment	:	Rs. 15,000 (1987)
Cost of operation	:	Rs. 35/q (1987)

(b) Manual Dough Mixer

The equiptment, shown in Fig. 5.36 has been developed at CIAE, Bhopal for kneading of soy-wheat flour dough It is a hand operated machine which consists of two metal prongs to perform kneading operation. A stationary metalic bowl is fixed at the bottom o' mixer in which prongs revolve to knead dough. The prongs are rotated

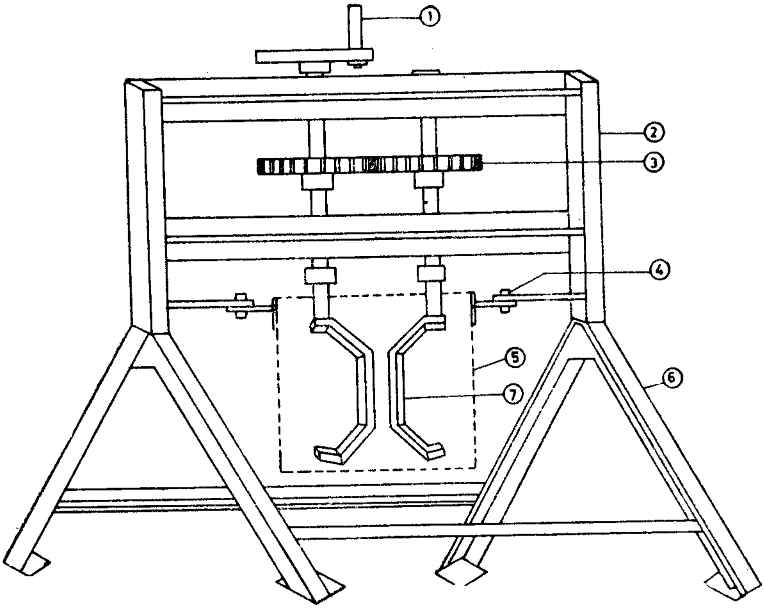


Fig. 5.36 Manual Dough Mixer

1. Handle 2. Frame 3. Gear 4. Container Holding System 5. Container 6. Stand 7. Prong

through gears by handle provided at the top. The technical details of this equipment are :

Overall dimensions	:	950 mm × 700mm × 600 mm
Capacity	:	1 kg/batch and 6 kg/h
Kneading time	:	7 mm for soy-wheat flour in 10 : 90 proportion
Labour required	:	One
Cost of equipment	:	Rs. 500 (1988)

(c) Power Operated Dough Mixer

CIAE, Bhopal has also developed a power operated dough mixer. The machine (Fig. 5.37) consists of a single steel arm rotating in a stationary container in multi directional manner with gyratory motion

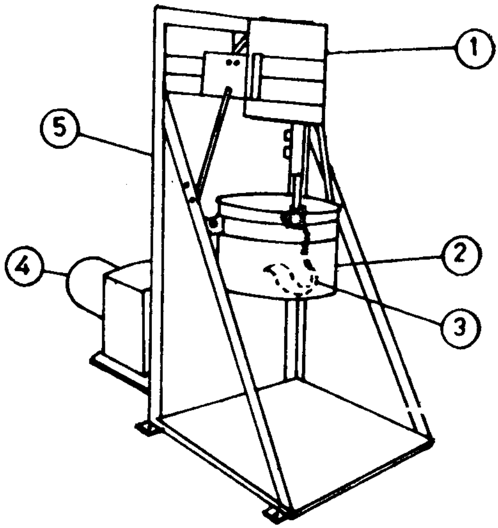


Fig. 5.37 Power Operated Dough Mixer

1. Gear Set 2. Dough Container 3. MIxing Arm
4. Electric Motor, 1 hp 5. Frame

through ecentric disc. The gear system is enclosed by a metallic cover to avoid contamination with food material. The other technical specifications and test results of this equipment are :

Overall dimensions	:	1,000 mm × 840 mm × 510 mm
Power required	:	1 hp
Capacity	:	3 kg/batch, 36 kg/h
Kneading time	:	3 min/batch
Kneading speed	:	680 rpm
Labour required	:	One
Cost of equipment	:	Rs. 3,000 (1987)

(d) Paneer Pressing Devices

For preparation of paneer from soymilk, CIAE, Bhopal has developed following 3 equipments,

(i) Domestic Level Paneer Pressing Device

This equipment (Fig. 5.38) is fabricated from MS angles and plates with chromium plating. The device consists of a frame

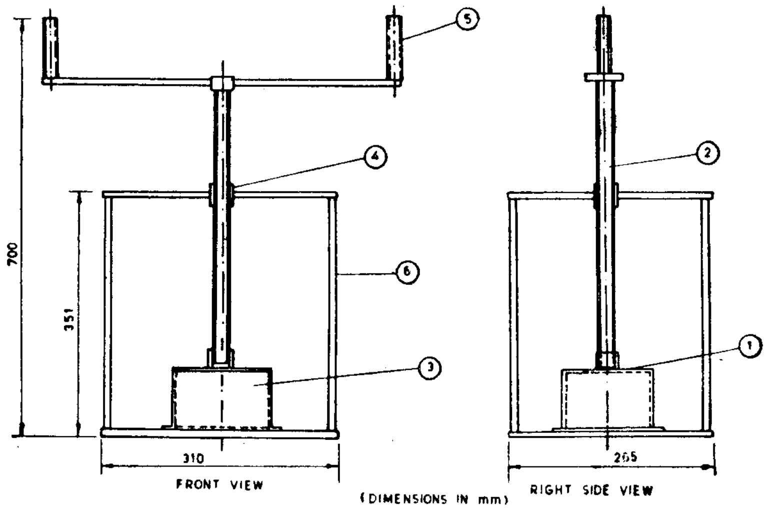


Fig. 5.38 Domestic Level Paneer Pressing Device

1. Weight 2. Screw Shaft 3. Paneer Box 4. Sleeve 5. Handle 6. Frame

Dimensions in mm

supporting screw with handle and a perforated plateform with guide reaps. The coagulated soymilk in the flour layered cheese cloth is kept in the box with a plate on it. The pressure is applied on the coagulated soymilk through the plate by a screw. The pressure can be controlled by lengh of travel of screw to get uniform quality of paneer. This simple device can produce 6 kg paneer/h at domestic level. The specifications and test results of the equipment are given below.

Type	:	Single box, screw press
Overall dimensions	:	310 mm × 265 mm × 700 mm
Capacity	:	2 kg/batch, 6 kg/h
Pressing time	:	15 min.
Labour required	:	One
Cost of equipment	:	Rs. 500 (1988)

(ii) Lever Type Paneer Pressing Device

This equipment filters soymilk from slurry, presses paneer and cuts it into cubes. The equipment, shown in Fig. 5.39 consists of a

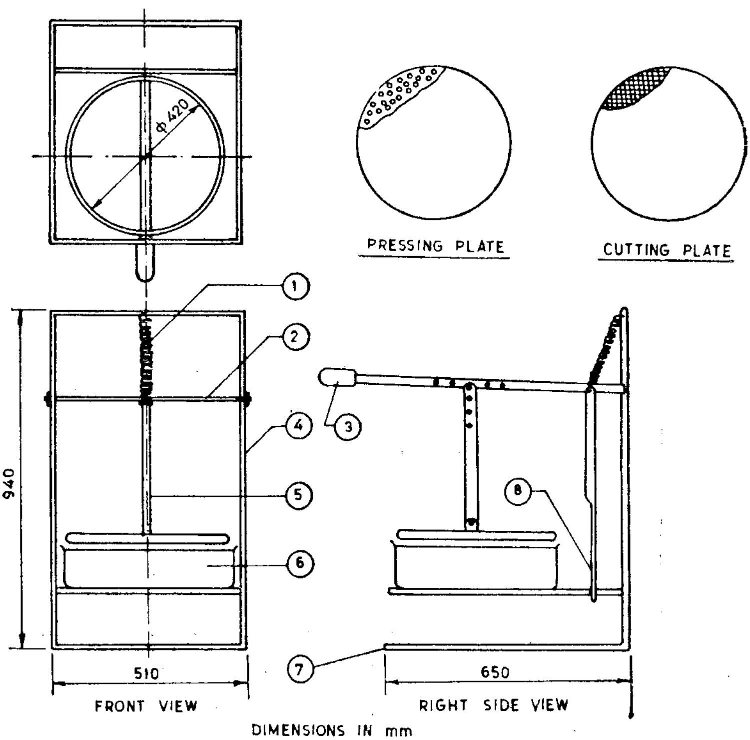


Fig. 5.39 Lever Type Paneer Pressing Machine

1. Spring 2. Tie Rod 3. Lever 4. Stand 5. Actuating Lever 6. Paneer Box 7. Base 8. Position Adjuster

Dimensions in mm

frame, circular box and a lever operated pressing plate. The peg type plates can be fixed in place of plain pressing plate as per requirements. The soy slurry is poured in the box and pressure is applied by the plate to separate milk which is collected in a container kept below. The required pressure can be obtained by adjusting the lever movement. In the same box, with 4 layered cheese cloth paneer can be pressed to separate whey, with plain as well as peged plate. The cubes are cut by putting the plate with knives/cutting edges. This is a three-in-one unit suitable for cottage level production of soypaneer. The specifications and test results of this equipment are :

Overall dimensions	:	650 mm × 510 mm × 940 mm
Dia. of box	:	420 mm
No. of pressing plates	:	3 (plain, with pegs, with cutting edges)
Capacity	:	5 kg/batch/h
Labour required	:	One
Cost of equipment	:	Rs. 800 (1988)

(iii) Screw Type Paneer Pressing Device

Developed for pressing the coagulated protein in the form of cubes, the unit (Fig, 5.40) consists of 8 paneer pressing boxes, a frame and screw with handle. The coagulated soymilk with whey is filled in the boxes on 4 layered cheese cloth, The boxes are placed in the base provided for firm grip while pressing. The pressure is exerted by the plates attached to common centrally located screw which is lowered by rotation with handle. The whey after pressing is collected in a tray provided below the frame. The equipment has following specifications and test results.

Overall dimensions	:	1,020 mm × 610 mm × 1,200 mm
Number of boxes	:	8
Capacity	:	16 kg paneer/batch of 1 h
Labour required	:	One
Cost of equipment	:	Rs. 1,000 (1988)

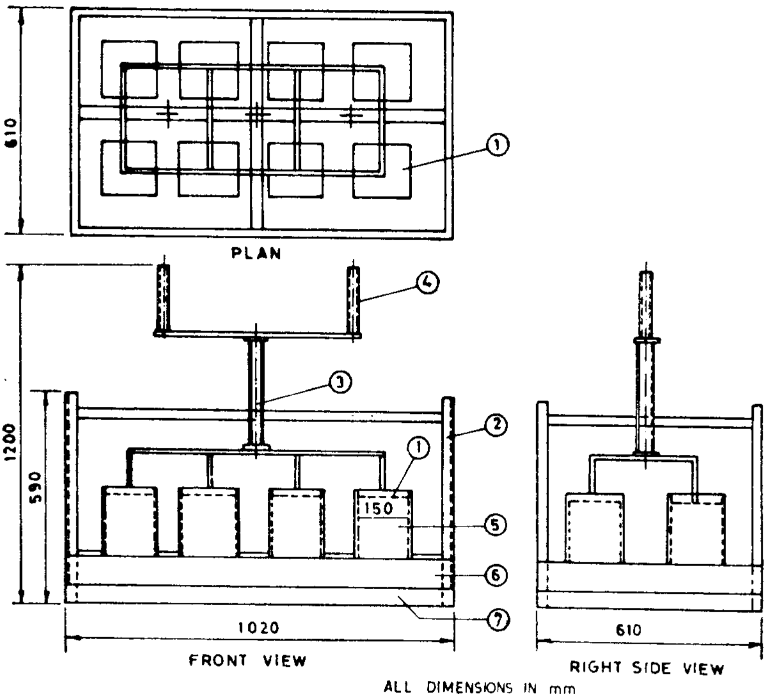


Fig. 5.40 Screw Type Paneer Pressing Device

1. Weight 2. Stand 3. Screw Shaft 4. Handle 5. Paneer Box 6. Base 7. Tank for Whey Collection

All Dimensions in mm

RAPESEED AND MUSTARD

The rape seed ranks fifth among the major oil seeds of the world. The cultivation of the plant for oil seed production is almost entirely confined to the temperate and warm temperate zone of Asia and Europe. Rape seed thrives best in rich soil in a cool and moist climate. Mustard seed in its various species of white, brown and black is a close relative of rape seed. It has been favoured for centuries in areas such as India and Pakistan while rapeseed is mainly grown in Canada, France, Sweden, Germany, Poland and U. K. In India, the major rapeseed/mustard growing areas are U. P., Punjab, Bihar, Rajasthan and Assam. It is grown as a mixed crop also.

Presently India produces over 2.64 million tonnes of rapeseed and mustard over an area of 3.8 mha. The oil content of the seed (undried) is around 40%. The spicy background flavour of the oil obtained from their seeds has ever been highly appreciated. This chapter describes the technology and equipment developed for drying, cleaning/grading, storage of seed, oil expression and storage of oil.

6.1 Drying

Moisture is a highly critical factor in the growth of bacteria and fungi. Rapeseed at 8% moisture achieves equilibrium with a surrounding atmosphere of 70% relative humidity at usual storage temperature. If rapeseeds are harvested at some 20% moisture level, they need to be dried so as to safeguard against mould growth. Leaving the cut plants to dry in the fields (swathing) may achieve sufficient drying to permit-immediate bagging and storage of seed. In India the rapeseeds are usually harvested at a moisture content of about 30-35%. After harvesting, it is left for some days in the field along with the plants. The plants dry to 20-25% moisture level in the field at which the seeds are threshed. However, the optimum moisture content for threshing is 12-20%.

6.2 Cleaning and Grading

For separation of dust, dirt, stones, chaff etc. from good quality rapeseed/mustard seeds, the pedal/power operated air screen cleaners developed at CIAE, Bhopal may be used. The size of sieves recommended for this purpose are 3.1 mm for scalper and 1.4 mm for grader sieves used in both equipment. The pedal operated cleaner gives an output of 500 kg/h while the power operated cleaner has a cleaning capacity of 584 kg/h with an average cost of Rs. 22/t for cleaning the seeds.

6.3 Storage of Seed

The storage situation for different moisture levels of rape seed/mustard seeds in brief are as follows :

Below 6% M. C.	:	too dry as seeds may early crack, release oil and hence FFA % increases.
7%	:	safe for one year, will not encourage cracking.
8%	:	safe only for few months.
9%	:	may be safe in the short term but risk of moulding is greater. Seed equilibrates with atmospheric Rh above 70%.
11%	:	Continuous aeration is essential.
16%	:	Safe for about 2 weeks only if at 15°C and a steady air flow of 15–30 $m^3/h/t$ seed is provided (Nash, 1978).

Undried and uncleaned rapeseeds deteriorate quickly in bulk storage while clean and dried seeds store well. Studies on storage of mustard/rapeseed have been conducted at IIT, Kharagpur and JNKVV, Jabalpur as reported below.

Mustard seed (Brassica junca coss CV B-85) were stored in 4 indegenous storage struutures namely earthen pot, tar phinted polythelene lined bamboo bin, bamboo cement bin and metal bin at Kharagpur. These structures were sealed after filling with mustard seeds. The whole room as well as structures were disinfected by spraying maiathion (1 : 15 by volume @ 3litres/300 m² surface area) 24 hours before keeping seeds the inside them It was noted in 120 days storage that the moisture content of mustard seeds increased with storage time as shown in Fig. 6 1. The degree of rise was highest for seeds kept in tar painted bin and least in case of metal bin. As the

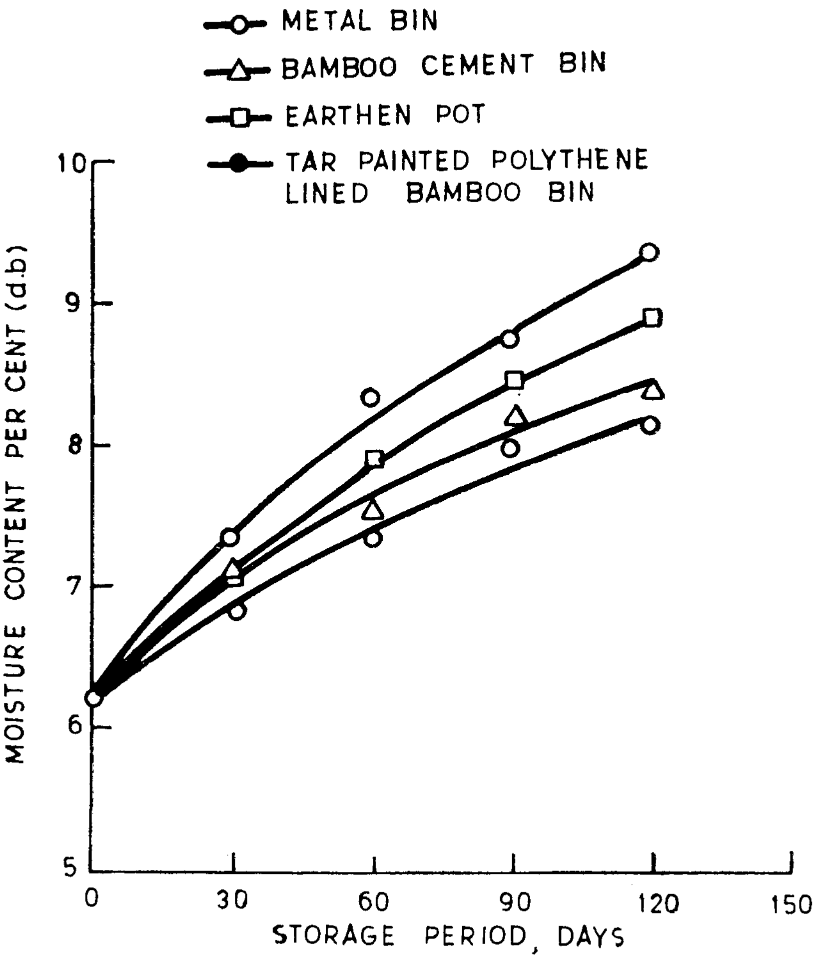


Fig. 6.1 Moisture Content of Mustard Seed Stored in Different Storage Structures

seeds became aged, there was a continuous loss in dry weight of seed stored in all the structures. This loss was maximum in taı painted bin and minium in metal bin, as shown in Fig. 6.2. Influence of ageing

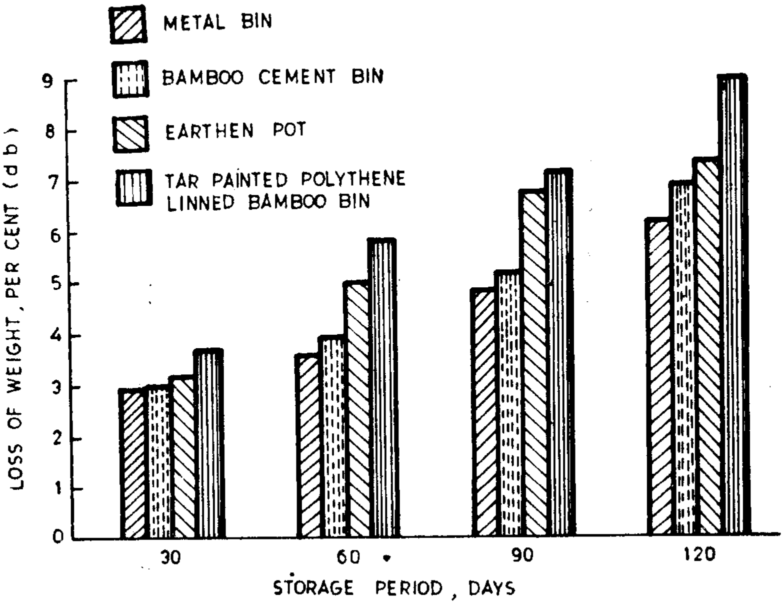


Fig. 6.2 Loss of Weight of Mustard Samples Stored in Different Storage Structures

on germination, root and shoot lengths heve been represented in Fig. 6.3. All these three parametres decreased alongwith storage time irrespective of storage structures used. So far as germination of seeds is concerned, metal bin was reported to be the best in maintaining viability while tar painted bin was worst. Appreciable changes were observed in the root length of mustard Fig. 6.4. Iodine value of mustard oil contained in the seed during 120 days storage incraased insignificantly in metal bin compared to other storage structures as shown in Table 6.1.

The reduction in iodine values at the latter part of ageing (90 and 120 days) for seeds stored in earthen pot and tar painted bin may be attributed to the oxidation of free fatty acids while lesser extent of a

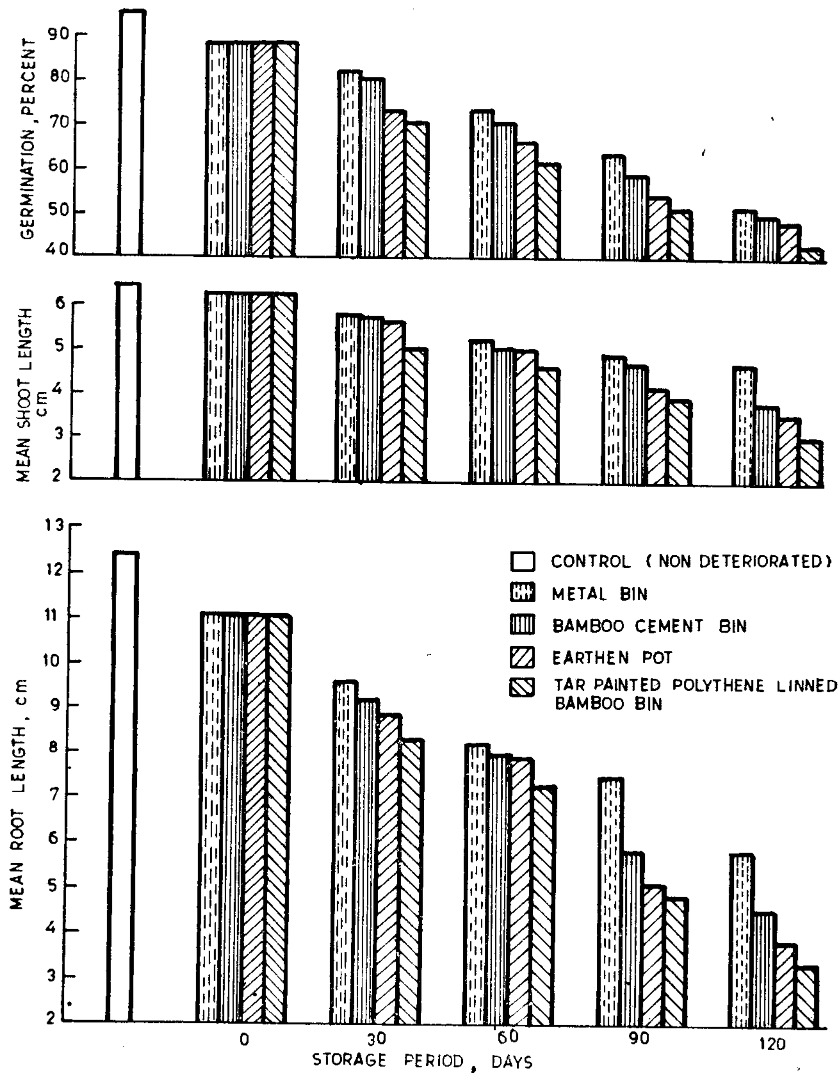


Fig. 6.3 Influence on Storage period on Root Length/Shoot Length and Percent Germination of Mustard Samples Stored in Different Storage Structures

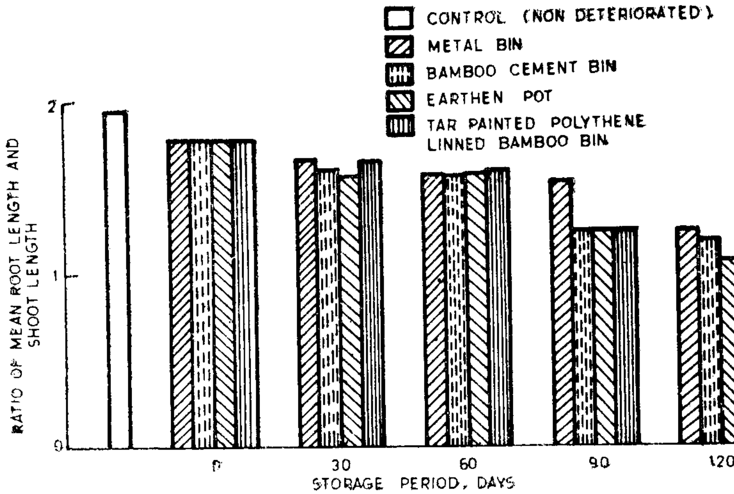


Fig. 6.4 Ratio of Root Length and Shoot Length of Mustard Samples Stored in Different Storage Structures During the Storage Period of 120 Days

fatty acids may have been available for the access of iodine within the seed molecule. In case of metal bin and bamboo cement bin, perhaps the deterioration was much less to avoid the cleavage of FFA and that is why a continous increase in iodine value was observed.

Table 6.1 : Changes in iodine value of mustard seed during 120 days storage in different structures

Storage period days	Iodine value of mustard stored in			
	Metal bin	Bamboo cement bin	Earthen pot	Tar painted PE lined bemboo bin
0	106.24	106.24	106.24	106.24
30	106.28	106.75	106.S9	107.05
60	106.35	107.01	107.55	108.31
90	106.42	107.56	107.99	107.59
120	106.58	107.92	107.23	107.02

The saponification value of oil of seeds stored increased in the similar way to that of iodine value for metal bin and bamboo cement bin for 120 days and for earthen pot and tar painted polythene lined bamboo bin upto 90 days and then declined in both the cases as shown in Table 6.2.

Table 6.2 : Changes in saponifidation value of mustard seed stored in different structures for 120 days

Storage period days	Saponification value of mustard stored in			
	Metal bin	Bamboo cement bin	Earthen pot	Tar painted PE lined bamboo bin
0	174.50	174.50	174.50	174.50
30	174.00	174.92	175.10	175.60
60	174.25	175.32	175.83	175.99
90	174.92	175 65	176.52	177.86
120	175.01	175.83	176.00	175.93

The total oil content of mustard seed stored in above structures for 120 days did not change much because of ageing of seeds as shown in Table 6.3.

Table 6.3 Total oil content and development of free fatty acid of mustard samples stored in different storage structures

Storage period, days	Total oil content, percent (db.)				Free fetty acid, % (db.)			
	MB	BCB	EP	TPB	MB	BCB	EP	TPB
0	50.65	50.65	50.65	50.65	4.25	4.25	4.25	4.25
30	50.48	50.39	50.12	50.07	5.02	5.16	6.79	7.68
60	50.43	50.42	50.09	50.12	5.99	6.37	9.03	10.21
90	50.26	50.19	49.73	49.62	6.83	7.02	9.38	9.89
120	50.10	49.97	49.51	49.28	7.08	7.37	5.06	3.92

MB : Metal bin
BCB : Bamboo cement bin
EP : Earthen pot
TPB : Tar painted PE lined bamboo bin

Table 6.3 also shows the development of FFA in seeds stored for 120 days in different storage structures. Metal bin and bamboo cement bin could resist the formation of appreciable amount of FFA, however, FFA rose very sharply between 30 to 60 days of storage and then decreased sharply during 60 to 120 days in earthen pot and tar painted polythene lined bamboo bin.

The informations on insect infestation of the mustard seeds stored in different structures are provided in Table 6.4. It may be noted that mustard seeds stored in tar painted polythene lined bamboo bin deteriorated very fast, however seeds were safe upto 30, 60 and 90 days respectively in earthen pot, bamboo, cement bin and metal bin. From this study it has been concluded that metal bin is the most suitable storage structure as far as keeping quality of the seed is concerned.

In the experiment conducted at JNKVV, Jabalpur to study the development and survival of insects, effect of different moisture levels and storage structures on storability of mustard seeds, it was observed that initial moisture content of 12% followed by 10 and 8%, was on the whole, favourable for completing the life cycle of *Fig. (Almond)* moth, *cadra cautella* w, in less number of days. As far as time required for development of insects was concerned, 60.5, 65.3 and 69 days respectivety were required for seeds stored at 12%, 10% and 8% moisture levels. During storage of mustard seed in gunny bags, baked earthen pitcher and plastic container, development of some webbed masses, weighing 0.08 to 0.32 g were also reported. However, mustard seed was least susceptible to attack of *Fig. moth.*

The effect of period of storage and moistnre level and their interaction was found to be non-significant. The oil content varied from 49 to 50% in gunny bag and between 48 to 50% in baked earthen pitcher and plastic containers, both, as shown in Fig. 6.5. The protein content of the seed also was not markedly influenced by storage period and moisture level. It varied from 18.01 to 18.39% in gunny bag, from 18.0 to 18.76% in plastic container and from 18 39 to 18.97% in earthen pitcher during 4 months storage as shown in Fig. 6.6. As far as free fatty acid content was concerned, it varied

Table 6.4 Insect infestation of mustard samples stored in different storage structures

Storage period, days	MB	BCB	EP	TPB
0	No infestation	No infestation	No infestation	No infestation
30	No infestation	No infestation	No infestation	Trace of infestation started with a little clot formation.
60	No infestation	No infestation	Little clot formation started.	A few insects are found with clot formation and change in flavour and odour.
90	No infestation	Very little clot formation, but a small number of insects are found	Little more clot formation with the change of odour and flavour.	Moderately infested by insects and some husks have been separated from seeds.
120	Very little trace of infestation started.	Some clot formation with insects. A little change in flavour and odour. Insects are moving Inside the structures.	Moderate clot formation. Many more insects are found. Some seeds separate from thin husks.	Severe infestation, clot formation. Most of the seeds have been damaged. A bad smell coming out.

MB : Metal bin, BCB : Bamboo-cement bin, EP : Earthen pot TPB : Tar painted PE lined bamboo bin

Source : PHTS Report JNKVV, Jabalpur

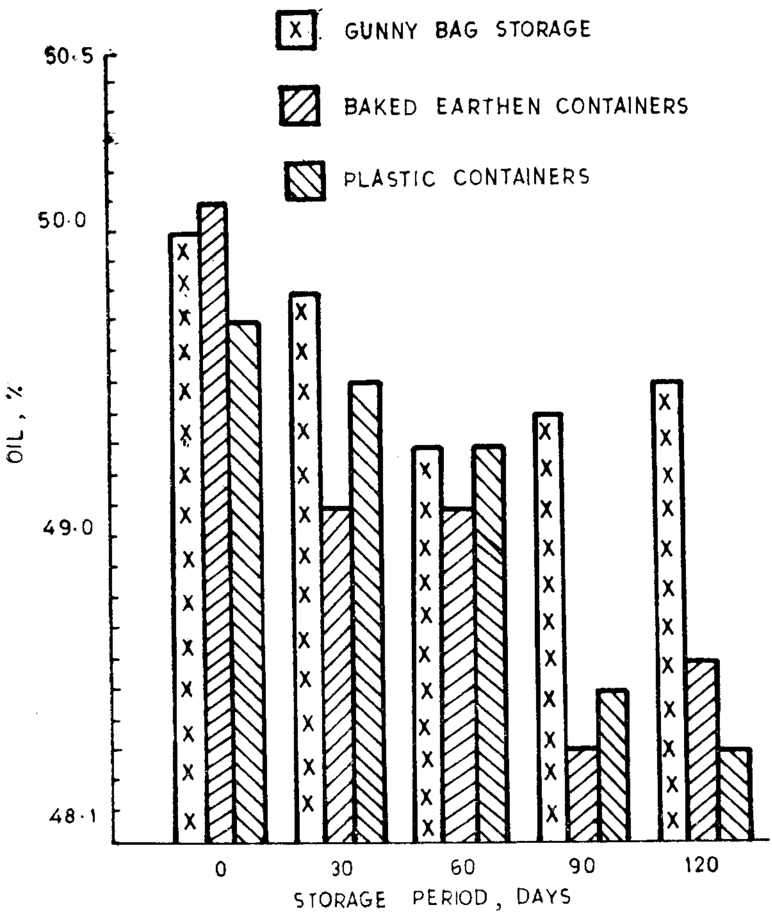


Fig. 6.5 Oil Content of Mustard in Different Storage Containers

from 3.25 to 6.87% in gunny bag andfrom 3.25 to 6.3% in both earthen pitcher and plastic container (Fig. 6.7). It was concluded that mustard with 6% moisture content does not allow insect development in plastic container due to air tightness and moisture proofness, compared to earthen pitcher and gunny bags.

6.4 Oil Expression

Studies have been conducted at GBPUAT, Pantnagar to determine the variations of oil out flow from a bed of rapeseed in relation to

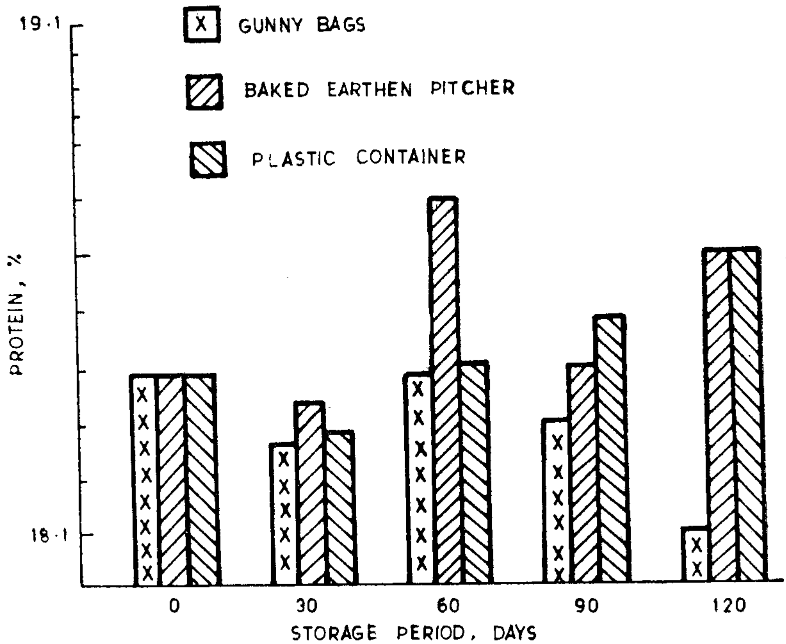


Fig. 6.6 Protein Content of Mustard in the Different Storage Containers

to different levels of moisture content and time of pressing under a constant pressure application. The study was conducted with T-9 variety of rapeseed, conditioned to 5.7 and 9% moisture levels, compressed at constant rate of deformation (23.74 cm/mn) under a static pressure of 68.215 kg/cm^2 in standard Carver Laboratory press of 25 t capacity for varying pressing times of 0,15, 30, 60, 90, 120, 180, 240, 300 and 360 seconds. In early stage of constant pressure application, both the deformation and oil expressed were rapid and tried to be constant as the pressing time varied in all moisture levels. The quantity of oil expressed had a linear relationship with the deformation (Singh and Singh 1985).

In tribal areas of the country, a local expeller, known as petula is used for extraction of oil from mustard seeds. This equipment, shown in Fig. 6.8, consists of two wooden planks and four wooden logs.

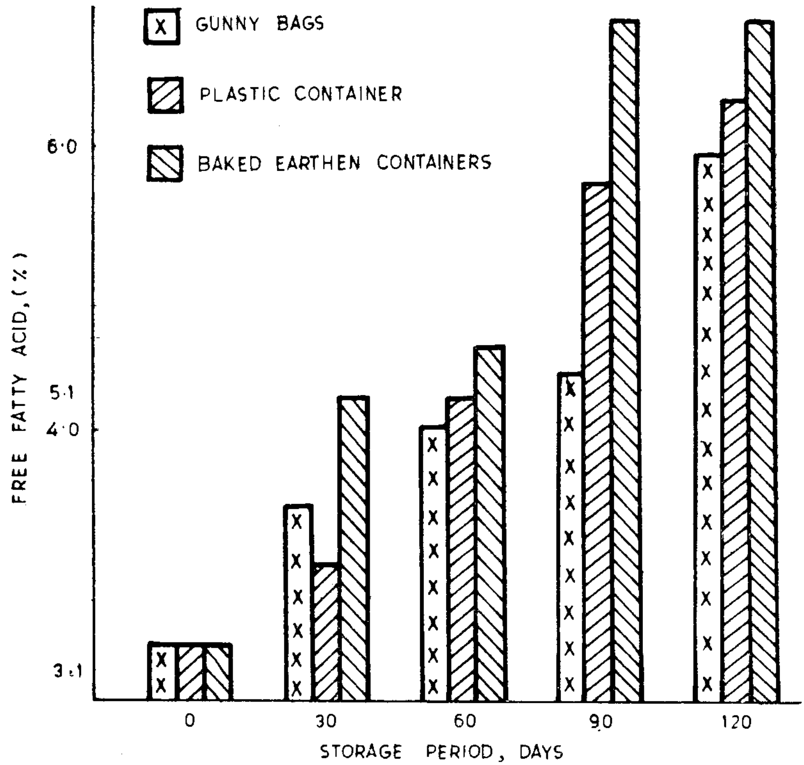


Fig. 6.7 Free Fatty Acid Content of Mustard Oil in the Different Storage Containers

Oilseed is loaded in jute cloth, steamed and then pressed in between two planks. A batch of about 2.5 kg seed takes about 1.5 h- in preparation and about 30 minutes in oil extraction giving about 0.5 kg oil. The capacity of petula ranges between 1.5 to 2.5 kg seed/batch. The traditional method of steaming the seed is shown in Fig. 6.9. JNKVV, Jabalpur has developed an improved equipment (Fig. 6.10) for this purpose in which steaming of 5-10 minutes only is required.

The traditional bullock operated ghani takes about 3 h to crush one charge of 16 kg mustard, producing cake with average oil content of 11-16%. Bullock drawn imporoved ghani, over head type

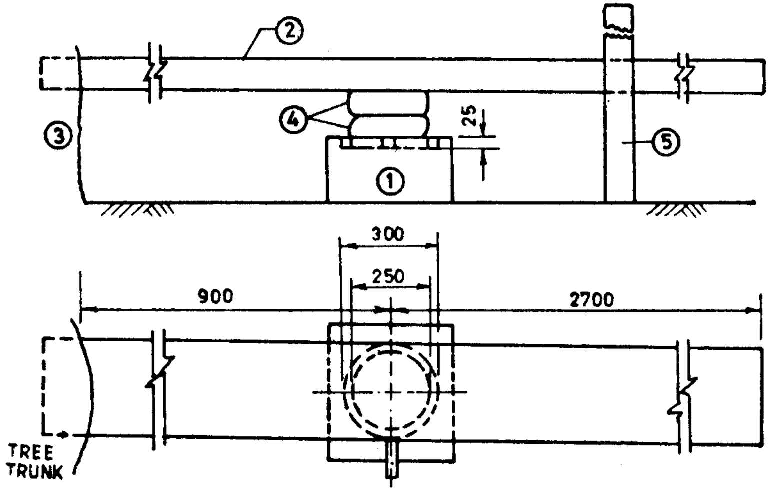


Fig. 6.8 Petula (Local Oil Expeller)

1. Bottom Slab 2. Beam 3. Support 4. Oil Seed Container 5. Wooden Guide Pole

power driven gheni and portable power ghanies, described in chapter 4, respectively take 150, 90 and 75 minutes to crush a batch of 6-10, 12-15 and 12-15 kg mustard respectively. Their crushing capacity/d of 8 h is thus 40-60; 60-80 and 70-90 kg respectively. As per studies conducted at Junagarh, using a portable rotary power ghani (KVIC make) for extraction of oil from mustard seeds, the oil recovery by mixing water at normal temperature (20°C) was 20% which increased upto 27% when water at higher temperature (70°C) was mixed while expelling. The energy consumption/batch of 10 kg seed, however, also increased from 1.0 to 1.5 KWH. RAU, Udahipur has also evaluated the performance of portable power ghani with 10 and 12 kg of oil seeds by mixing water at 27±2 and 90±2 °C respectively at two phases viz. phase-1 water continuously sprinkled slowly till the process ends and phase-2, water is added at various stages of expelling namely,

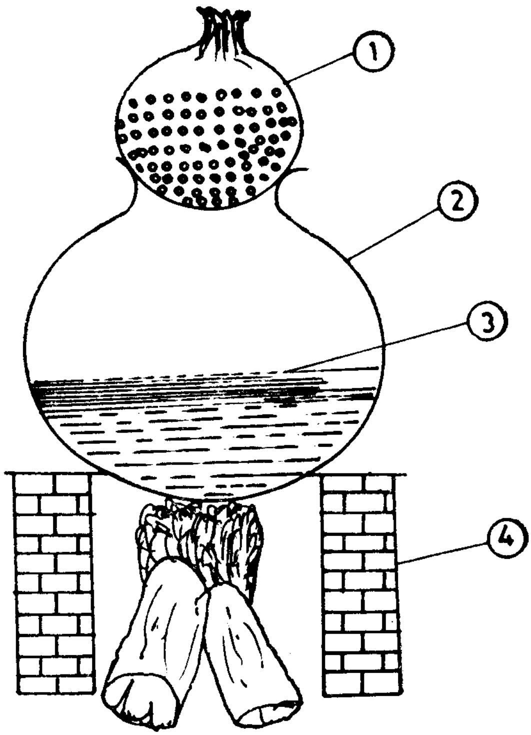


Fig. 6.9 Traditional Method of Steaming Oil Seed

1. Potli 2. Pot 3. Water 4. Sigri

I	stage	: at the stage of pulverization,
II	stage	: when cake formation starts,
III	stage	: when oil starts coming out of ghani and
IV	stage	: just before removing the oil cake

As shown in Table 6.5 it was observed that there was no effect of quantity of oil seeds crushed in ghani per batch. The total oil recovery was 66% with 10 kg batch and 67% with 12 kg batch when water at room temperature was added. However, the recovery increased to 77% in both cases when water at 90°C temperature was added. The time required for oil extraction also increased by about 20 min when feed

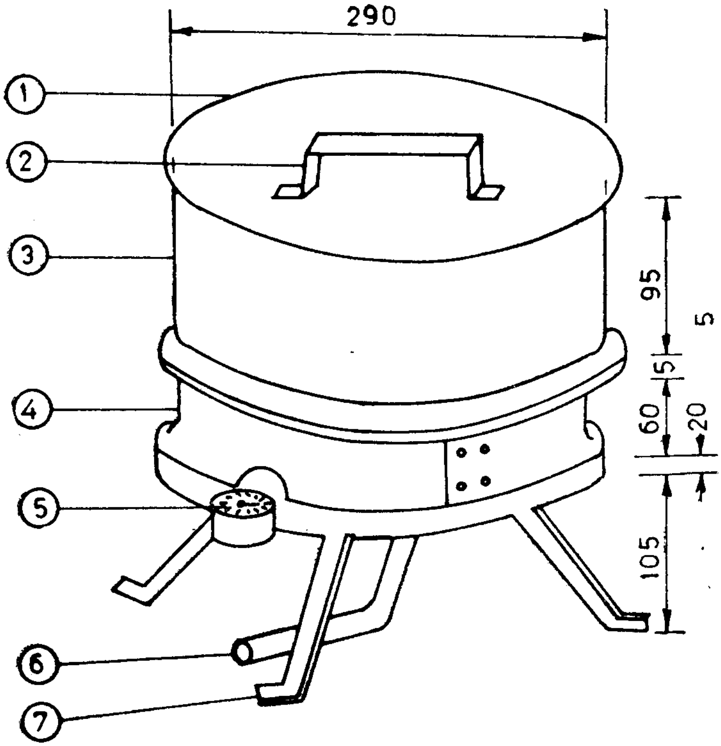


Fig. 6.10 Improved Steaming Equipment for Mustard

1. Cover 2. Handle 3. Steaming Chamber 4. Basket
5. Pressure Gauge 6. Plastic Pipe to Auto Clave 7. Stand

Dimensions in mm

rate was changed from 10 to 12 kg/batch but there was not much increase in power consumption/kg oilseed. The oil recovery, however, reduced when quantity of water added was increased. It was inferred that addition of 12-14% water in oil seed yields maximum amount of oil There was no significcnt effect of stage of water addition, however oil recovery increased by 1.25% when water was added in 4 stages instead of continious addition of water. (Annual Report of CTAE, Udaipur centre of PHT Scheme, 1984).

In some parts of the country, power driven rotary mills are used for extraction of oil from rapeseed/mustard. In this mill, both the pestle and mortar are made of wrought iron A bucket, rolled of 1–3 mm steel sheet is fitted on the mortar to serve as seed container. A ring of 25 cm inner diameter is seated on a saucer (which serves as oil bowl) to form the mortar. The top periphery of the mortar is fitted with ver. tical wooden pegs (15 cm long) which forms replacable scrappers The pestle is obliquely placed on the taper ring such that it leaves a clearence of 0.125 to 0.5 mm between the round ring depdending upon the seed. The pestle rotates due to friction with the rotation of the taper ring. Mortar is made to rotate from a shaft by means of a pinion working in a bevelled wheel, fixed to its lowet position. A power driven rotary mill (Fig 6.11) rotates at a speed of 14–16 rpm. The bucket has about 45 cm diameter at the top tappering to about 30 cm at the bottom. Pestle is about 75 cm long and the height of the rotary, mill from the bottom plate to the top is around one meter The oil flows from the tapper ring dripping on to an oil plate placed below it. A single rotary mill can be run with a 5 hp motor where as a 7.5 hp motor is required to run two such mills. A batch of about 20 kg mustard seed takes about 40 minutes to be crushed, yielding cake with 10–12% residual of oil after two crushings.

For commercial scale operation, screw expellers of different makes and capacities are manufactured in India by various manufacturers. Studies have been conduated by various centres of PHT Scheme to optimize the seed pre-treatment for optimum oil recovery from such expellers.

The JNKVV, Jabalpur has reported that simple pressing of oilseeds in expellers does not yield oil from rapeseed. In worm type expellers, oilseeds are pre-stressed, crushed and sheared simultaneously so the extraction of oil becomes easy. Pre-crushed and pre steamed seeds require less power for oil expulsion as compared to non-conditioned/pre-roasted/pre-steamed/pre-crushed seeds. Steaming of mustard seeds before extraction increases the oil recovery (by 4.6%) and the seed moisture content and also affects the visco-elasticity of oil. Steaming is found better than roasting of seed with regards to oil recovery. The

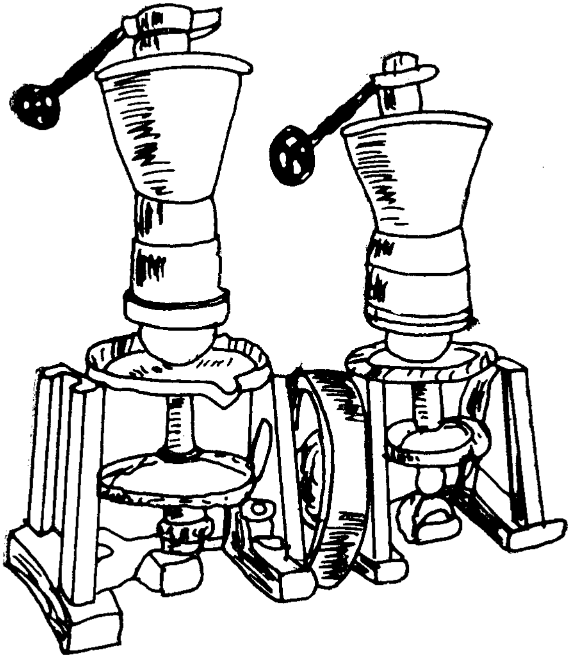


Fig. 6.11 Rotary Oil Mill (Kolhu)

optimum time for steaming is 5 to 10 minutes and the oil extraction efficiency increases by 7% by this pre-treatment of the seed. The steamed seeds require less energy for oil expelling.

Studies have been conducted at CIAE, Bhopal for extraction of oil from rapeseed using a Mini-40 oil expeller. Prior to expelling, the seed samples were given various treatments, viz water moistening, hot water soaking for one hour and one hour soaking followed by 10 minutes steaming. The moist samples of rape seeds, when dried to about 9.5 moisture level, gave the oil yield of 77.56%. Samples, soaked with hot water for one hour, when dried to 9.6% moisture level gave oil recovery of only 41.9% while samples soaked and steamed for 10 minutes, when dried to about 9.4% moisture level gave oil yield varying in between 54 to 74%.

RAU, Udaipur has evaluated the performance of a table oil expeller, manufactured by M/s S. P. Engg. Corp., Kanpur, for expelling oil from mustard seed. The expeller, shown in Fig. 6.12 has following specifications :

Overall dimensions	: 0.42 m × 0.80 m × 0.87 m
Worm shaft speed	: 45 rpm
Length of cage bars	: 0.125 m
Width of cage bars	: 0.012 m
No. of cage bars	: 16
Dia. of expeller pulley	: 0.36 m
Dia. of motor pulley	: 0.18 m
No. of teeth on small pinion of	:
Power transmission system	: 20
No. of teeth on big pinion	: 80
Rated power	: 2.3 KW
Recommended capacity	: 50 kg seed/h

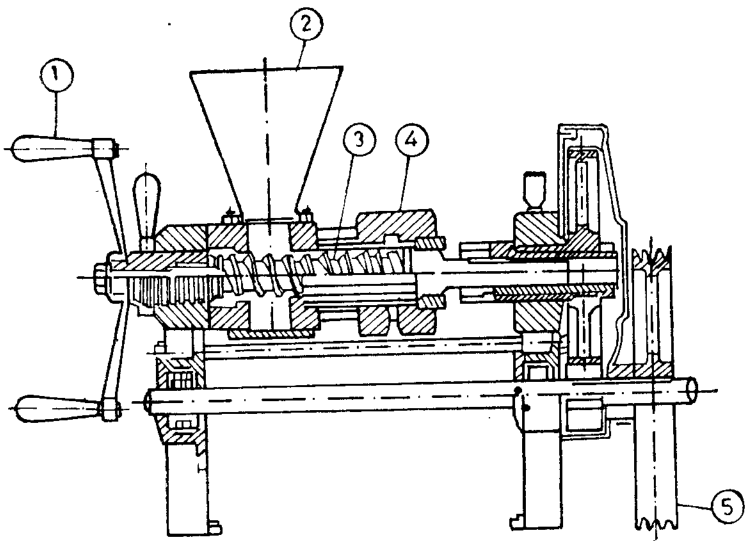


Fig. 6.12 Cross Section of Table Oil Expeller

1. Handle 2. Hopper 3. Worm Shaft 4. Drum 5. Pulley

Fig. 6.13 shows the details of the worm shaft of this table oil expeller.

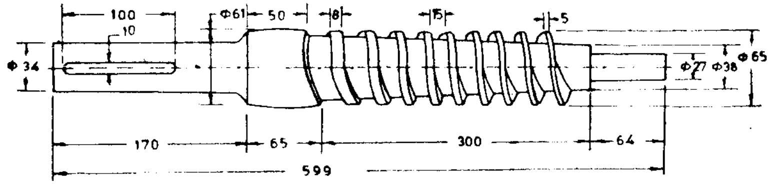


Fig. 6 13 Worm Shaft of Table Oil Expeller
All Dimensions in mm

The effect of initial moisture content and instant water addition on oil recovery, processing time and energy consumption were studied. These studies reveal that total oil recovery increased from 24.07 to 29.21% (seed basis) with increase in equivalent moisture level from 6 to 10%. In terms of oil content of seed, the recovery increased from 66.88% to 80.91% as shown in Fig. 6.14. In the range of 10 to 12%

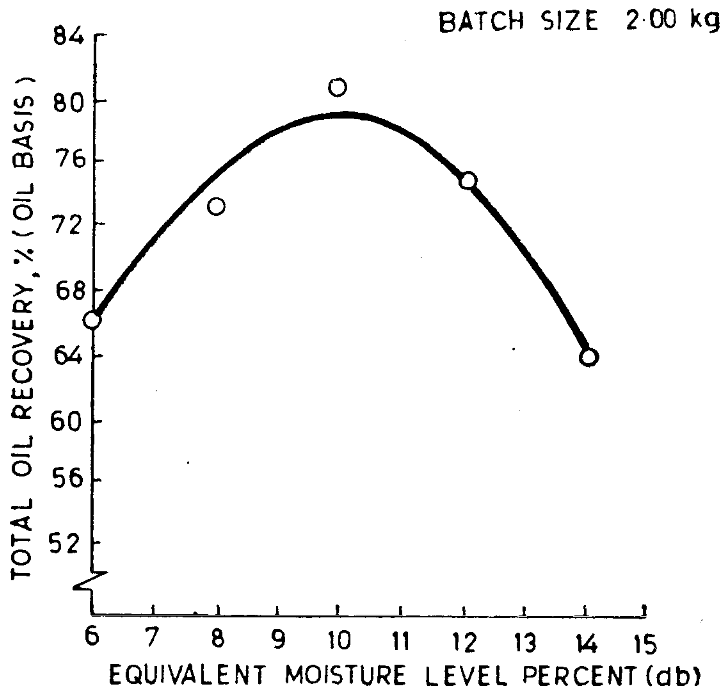


Fig. 6.14 Effect of Equivalent Moisture Levels on Total Oil Recovery

initial moisture level, maximum recovery of oil could be obtained from mustard seed. This increase in oil recovery may be due to the optimum level of moisture required for the appropriate physico-chemical changes during pressing. Moisture also works as heat transfer medium so the total heat generated by worm during pressing might be fully transfered to the individual fat globules which results in breakdown of the emulsion form of the fat and helps in releasing more oil droplets. The total oil recovery on instant addition of 4% moisture to initial 5.92% moisture level increases from 24% to 28% (seed basis) sa shown in Fig. 6.15.

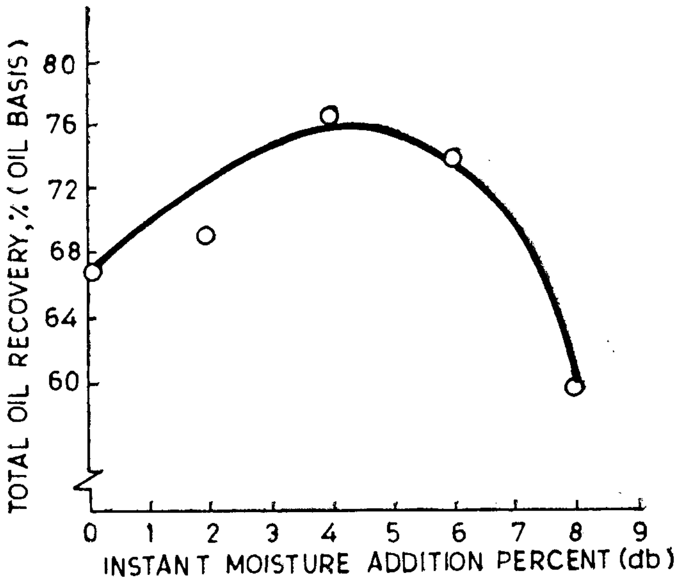


Fig. 6.15 Effect of Instant Moisture Addition on Total Oil Recovery

Beyond this, the oil recovery starts decreasing which shows that excess moisture is not favourable for optimum recovery. Total oil recovery at instant addition of water is lower than the initial moisture level's oil recovery. On instant addition of moisture to seeds, water may be absorbed by the seed coat rather than penetrating to the inner cells while moisture should penetrate to the inner cells to break emulsion of the fat globules. Oil recovery on different pressings also had much variation. During studies with equivalent moisture level, second pressing gave maximum oil recovery in comparison to other pressings whereas fourth pressing gives minimum oil recovery. The oil recovery increases upto 10% equivalent moisture levels whereas beyond it, the recovery decreases as shown in Fig. 6.16. This clearly shows that

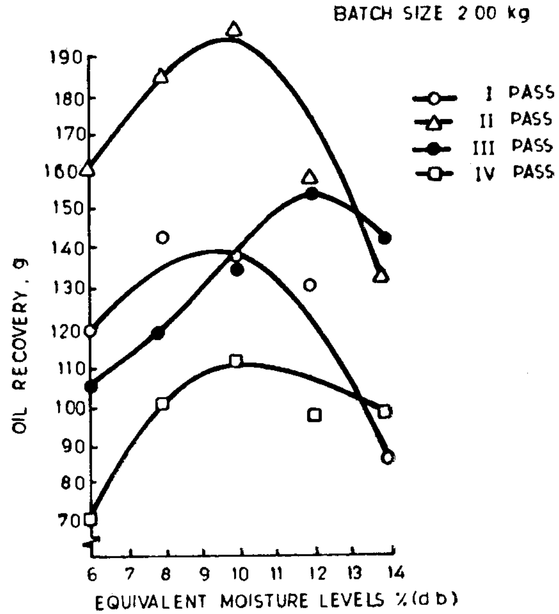


Fig. 6.16 Effect of Equivalent Moisture Levels on Oil Recovery in Individual Pass

excess moisture does not help in increasing the oil reeovery. Total energy consumed during various treatments had little variations as major part of the energy consumed is required to run the expeller ideally and a minor part of it is consumed to crush the seeds. Energy consumed in first and second pressing have decreasing trend on addition of instant moisture but in third and fourth pressing, total energy increases upto 4% moisture addition from 150 KJ to 165 KJ whereas beyond 4% level, it follows decreasing trend as shown in Fig. 6.17. Specific energy consumption started decreasing from 330 KJ to 300 KJ/kg of feed on instant addition of moisture as shown in Fig. 6.18. The decrease in

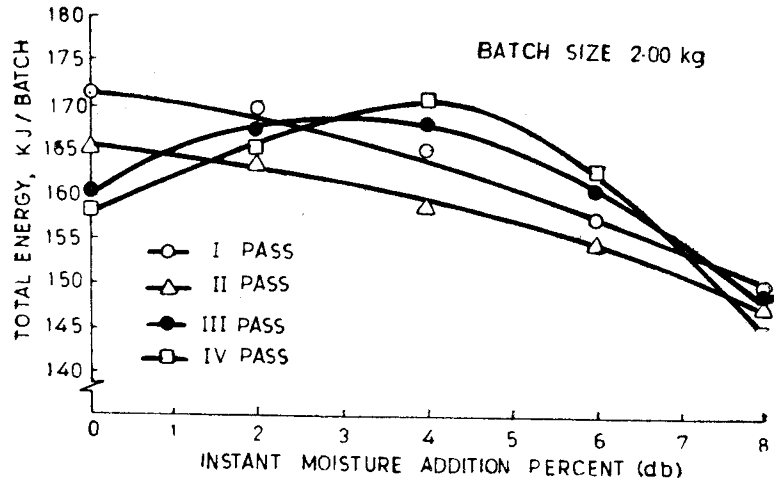


Fig. 6.17 Effect of Instant Moisture Addition on Total Energy Consumption of Individual Pass

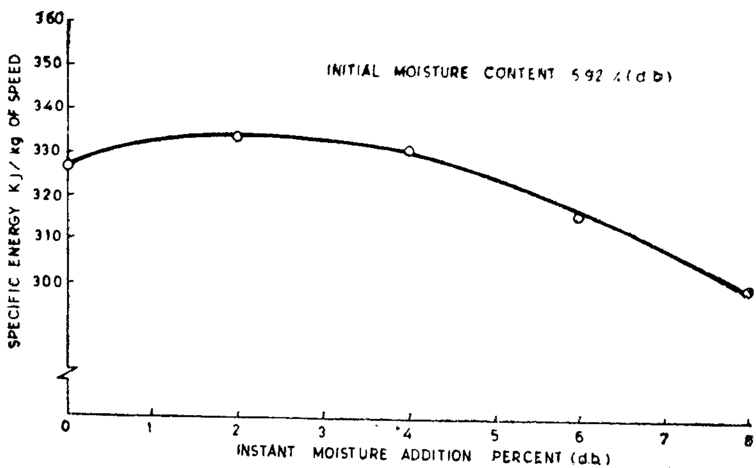


Fig. 6.18 Effect of Instant Moisture Addition on Specific Energy Consumption

enery might be due to increase in moisture as moisture also works as a lubricating agent. Residual oil in the deoiled cake is 3–4% lower than the difference between amount of oil available in the seeds and oil expelled as some of the oil sticks to the periphery of barrel.

A Super-Delux table oil expeller, manufactured by M/s S.P. Engg. Corp. Kanpur was evaluated at GBPUAT, Pant Nagar for expelling of mustard seed. The specifications of this expeller are :

Overall dimensions	: 1,140 mm × 550 mm × 960 mm
Weight	: 225 kg
No. of channels in chamber	: 1
No. of bars	: 22
Rated hp	: 5
Rated capacity	: 55 kg seed/h
No. of pressing required	: 3
Oil left in cake	: 7–8%

Figures 6.19 to 6.23 show the performance of the expeller under different operating conditions. The expelling process consisted of 3 successive pressings corresponding to warm clearence of 1.275, 0.9 and 0.5 mm. The oil recovery varied from 0-6.95, 0–19.38 and 1.76 to 19.25% in first, second and third pressing respectively. In general the oil recovery decreased with the increase in moisture content in the range of 5.9 to 14.2% indicating cohesive and elastic behaviour of high moisture seeds (Fig. 6.19). The oil recovery was higher in the second pressing than in the third pressing for moisture level upto 10.7% whereas the trend reversed in the higher moisture levels.

Maximum energy was consnmed in the first pressing where oil recovery was relatively less which showed that most of the energy was consumed in the crushing of seed and formation of cake rather than in actual oil expression. It was also noted that energy consumption was minimum in second pressing where maximum oil recovery takes place. The enargy requirement of individual pressings were approximately 42.46, 20.24 and 33-40% respectively of the total energy consumption in first, second and third pressings. The energy consumption was

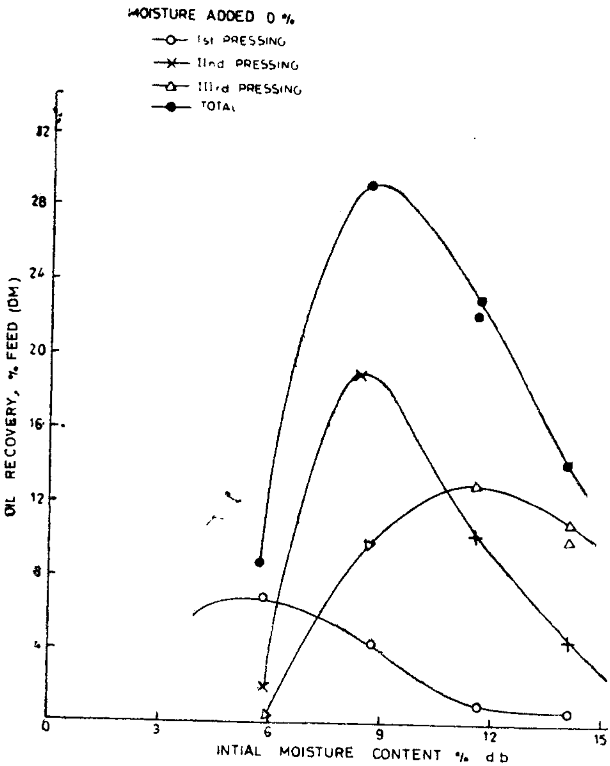


Fig. 6.19 Effect of Seed Moisture Content on Oil Recovery at no Moisture Addition

influenced by the extent of moisture addition as shown in Fig. 6.20. The study showed that cold pressing of rapeseed should be done if the moisture level of seed ranges between 9–10% though energy consumption may not be minimum in this process but higher oil recovery may compensate the same.

The effect of speed on oil recovery, energy and capacity utilization was also studied at seed moisture content of 7% (db) with 32% instant water addition i. e. seed moisture content of 10%. At this moisture, the oil recovery was found to be maximum, Fig. 6.21 shows

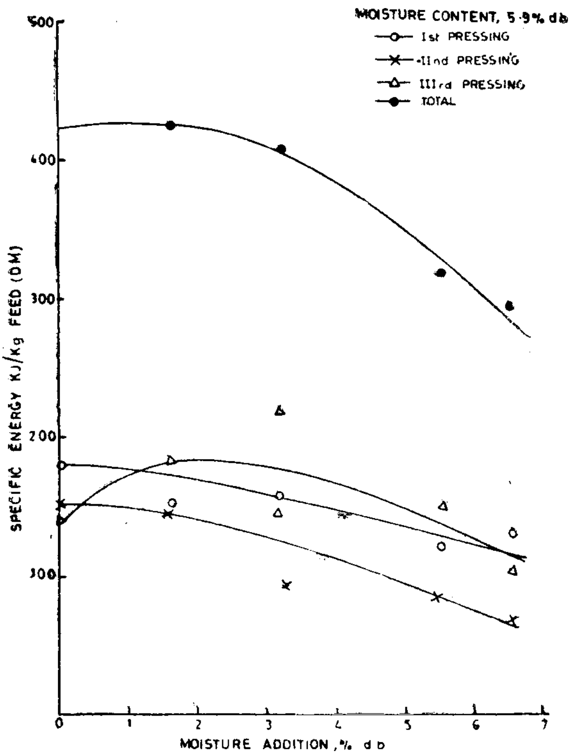


Fig. 6.20 Effect of Moisture on Energy Consumption

the relationship between speed and sluge, oil and solid recovery from expeller. The behaviour of sludge recovery with speed could be divided into two ranges, 350 to 425 rpm and 450-530 rpm. In the first range, the sludge recovery decreased with speed at an increasing rate whereas in the second range the sludge recovery decreased with speed at a decreasing rate. There was a sudden increase in sludge recovery between 425-450 rpm. Similar trend was observed in case of oil recovery with changing speed. The oil recovery varied from 27.8% to 21.5% with an average recovery of 24.8%. As shown in Fig. 6.22, minimum energy requirement was observed in the speed range of 425-450 rpm. Fig. 6 23 shows the relationship between the speed and capacity Which increased from 35 kg/h to 48.5 kg/h. (rated

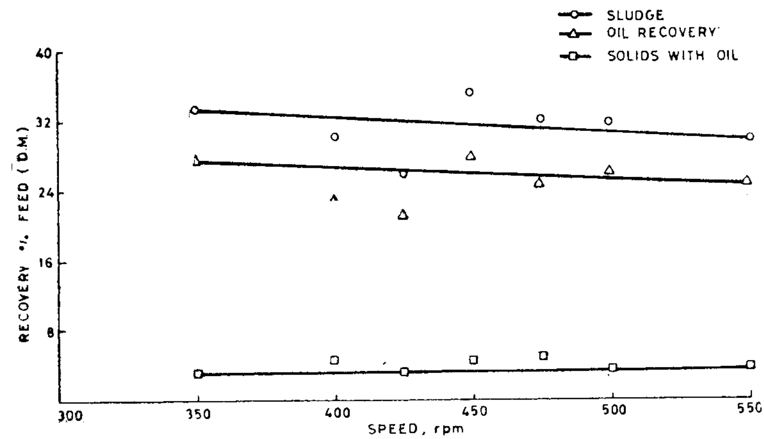


Fig. 6.21 Effect of Speed on Recovery

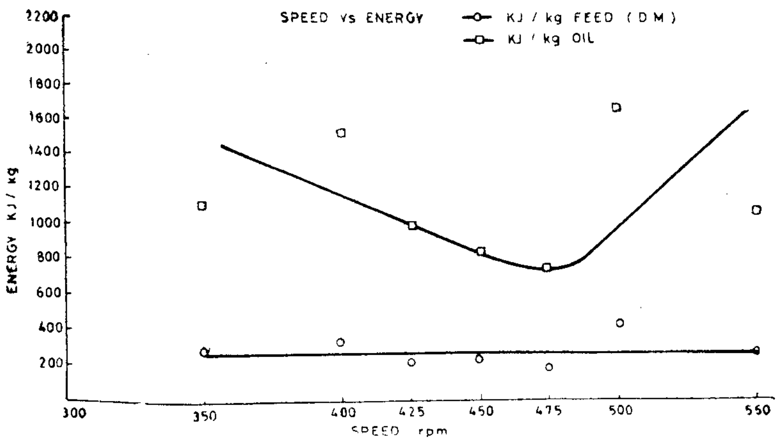


Fig. 6.22 Effect of Speed on Energy

capacity of expeller 50 kg/h). The study thus showed that the speed does not have any significant effect on oil recovery.

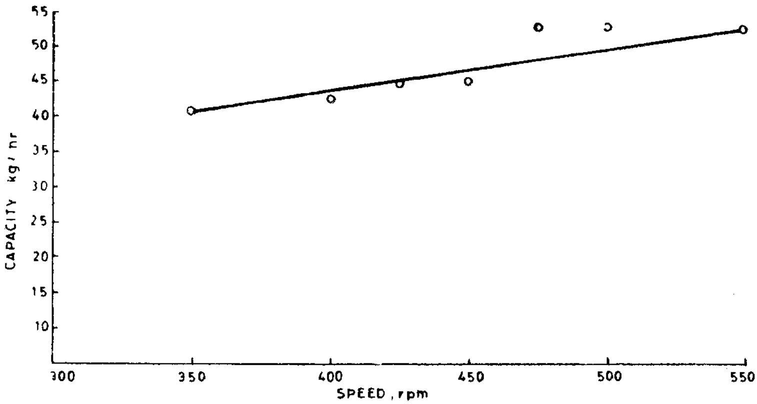


Fig. 6.23 Effect of Speed on Energy

The energy consumption is observed to be minimum at 425 to 450 rpm when expressed in terms of KJ/Kg of oil. The capacity increases with speed from 35.8 kg/h at 350 rpm to 48.5 kg/h at 550 rpm. The cold pressing of rape seed, thus, should be done at 9-12% moisture with approximately full capacity which is available at 450 rpm. If the moisture content of seed is less, additional constant moisture would be added to raise the moisture content of the seed upto 9-12% (Annual report of PHTS, GBPUAT, Pant Nagar 1984).

Cake Utilization

There is a great potential for preparation of high quality oilseeds protein concentrate from mustard, though there are number of problems too. The oil from mustard is known for its pungent flavour which is developed during milling through the control of moisture. While this flavour is highly apereciated by the consumers, it is very much undesirable in the protein concentrate. The presence of iso-thyocyanates and their toxicity is not desirable in the protein meal. A considerable amount of work is in progress for modification of the milling process and on removal of toxic components for better use of the protein meal. (Parpia, 1988).

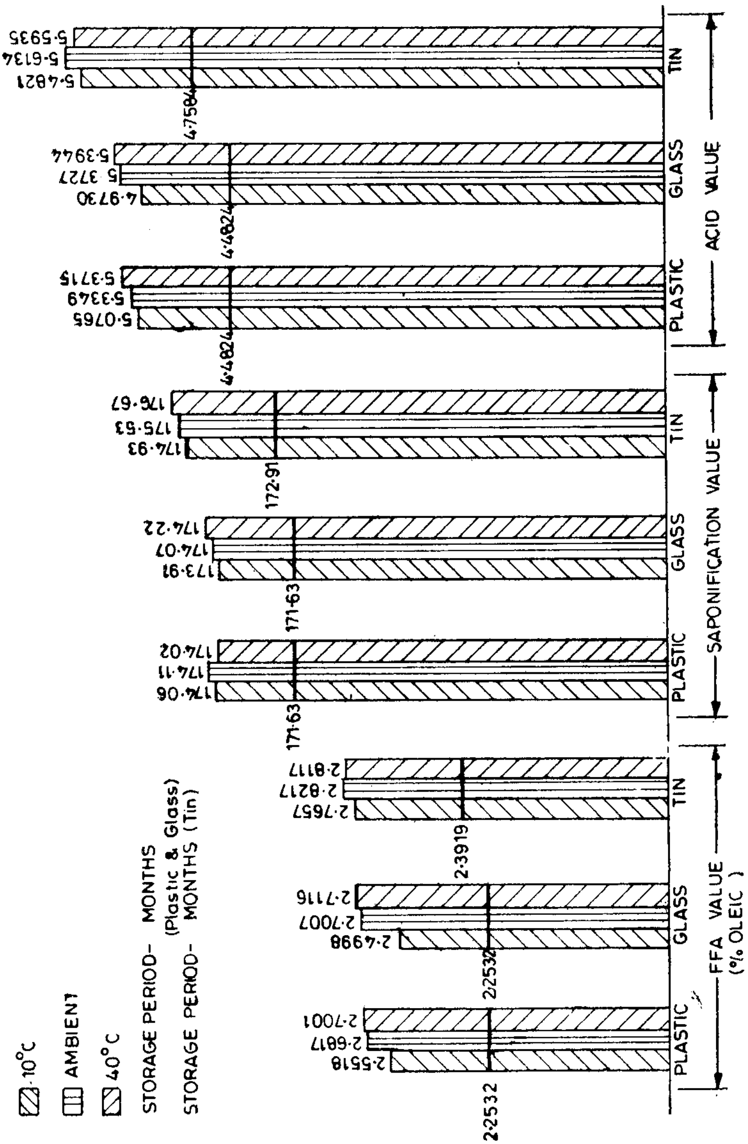


Fig. 6.24 Variation in Bio Chemical Parameters of Mustard Oil Stored in Various Containers For 7 Months at Different Temperatures

Storage of Oil

Kumar et. al. (1989), have studied the suitability of various flexible pouches viz. LDPE, Nylon 6 ionomer, polyster (PET)/HD-LD PE etc. for storage of mustard oil at accelerated (38°C and 92% RH) and normal (27°C and 65% RH) conditions. At CIAE, Bhopal storage study of crude mustard oil has been conducted in plastic, glass and tin containers at ambient, 10°C and 40°C storage conditions. The variation in bio-chemical parameters viz., FFA, acid value, saponification value etc. were recorded in one month interval to access the quality of oil during storage. Study revealed that mustard oil could be safely stored for 9 months in glass, plastic and tin containers, as the variation in various bio-chemical parameters was within the safe limit. Controlled temperatures of 10°C and 40°C was found more suitable as compared with storage of oil in ambient condition. Likewise, the plastic container was found better among the other two containers. However plastic container and 10°C temperature are better container and storage condition for storage of crude mustard oil. Fig. 6.24 shows variation in qualities of crude mustard oil stored in above containers (Srivastava et. al. 1990).

7. SAFFLOWER

Large scale cultivation of safflower, containing 35 to 45 percent oil, has started about 25 years ago in India. Traditionally known as source of dye in ancient India, the safflower has attained considerable importance as an oilseed crop. It is cultivated in many states of India and numerous races of this crop are under cultivation, varying markebly in botanical features and in oil and dye contents. It is highly branched, herbaceous, thistle like annual, the spinous variety of which is valuable particularly for oil production. Safflower is mostly cultivated as a rainfed crop in the country and is drought resistant and can even be grown on poor sandy soils. At present, India produces over 4,29,00 t safflower seed from an area of 7,82,000 ha. Table 7.1 presents the content of hull and embryo (kernel) in the seeds of safflower varieties produced in India.

Table 7.1 : Content of hull and embryo (kernel) in the seeds of safflower varieties in India.

Variety	Hull %	Embryo %	Actual oil % in		
			Hull	Embryo	Whole-seed
JSF-1	51.8	48.2	2.0	63.5	31.0
Tara	51.7	48.3	1.5	59.0	30.0
A-1	57.0	43.0	1.5	59.0	30.0
K-1	50.1	49.9	2.0	59.0	27.5
No-83	55.5	44.5	2.0	60.0	31.0
JL-28-1	52.9	47.1	2.5	59.0	29.0
BE-356	51.7	48.3	2.0	61.5	20.0

Source : Sawant, AR and BM Moghe, 1985. Breeding Research on Safflower in Madhya Pradesh. Proc. Second Oil Crops Network Workshop held in Hyderabad, 5-9, 1985, 96-114.

Unfortunately, being a new crop identified for edible oil, very littele attention has been given towards development of modern technology on various post-harvest aspects of safflower viz, threshing, cleaning and grading, decortication, drying, oil expression, by-product utilization etc.

Traditionally the safflower plants are pulled out from field when most of its leaves have turned brown. Plants are uprooted manually, heaped for a few days to dry, threshed by beating with sticks and cleaned by winnowing. For safe-storage, the moisture content of seed should not exceed 8% (wb). The oil content in seeds is the most important product. Oil quality as well as the value of seed cake are enhanced, if the oil is expelled/extracted after removing the white, tough and horney coat. The hull (enveloping the kernel seed) is partially decorticated using roller mills followed by screening and aspiration. Usually 10 percent unhulled seeds are recommended for efficient processing. The oil is extracted either by subjecting the seeds to cold dry pressure in a country oil press or by hot dry distillation. In the latter method, the seeds are placed in an earthen pot, which is inverted over the mouth of a similar pot covered by a perforated plate and burried in the ground. Fuel is piled around the inverted pot and ignited. When the seeds get partially roasted, the oil drains down into the lower pot. In more modern methods, oil is extracted by continuous press, combination of continuous press and solvent extraction or by direct extraction. Hydraulic presses and screw presses are also used in some countries for this purpose. The oil is refined using conventional equipment usually centrifuges. The characteristics of oil obtained from dehusked seed after extraction are sp. Gravity 27° — 0.9242, saponification value — 192, iodine value — 136 2, acid value—6.3, acetyl value—13.2, hexabromide value—O.2 and unsaponifible matter—1.3%.

The oil obtained by cold expression (20% yield) is golden yellow in colour and has the analytical values, as sp. gravity 28°—0.9204, acid value—1.4, sap. value—190.7, iodine value—139.5, acetyl value—15.67, and unsapon. matter—0.02. The oil obtained by hot distillation is black and sticky and unsuitable for edible purpose. However, the yield is reported to be 25% higher than that by the cold press.

Generally when whole seeds are crushed for expressing oil, the cake produced, contains large amount of fibre and is unfit for human/animal consumption. The cake obtained from decorticated seeds (40% protein) is used for cattle feed while that obtained from undecorticated seeds is used for manurial purposes (20–22% protein). The cake does not get rancid, If stored in dry condition. Its application as manure greatly improves the physical properties of heavy soils. The seed and cakes are used as poultry feed. Safflower flour also contains lignan glycosides which import a bitter flavour and has cathartic activity. These can be eliminated or reduced to a low level in the preparation of concentrates or isolates (Bestchart, 1979). Fig. 7.1 shows the process chart of safflower processing.

7.1 Post Harvest Losses

Studies have been conducted at PKV, Akola, under All India Coordinated ICAR Scheme for Harvest and Post Harvest Technology to assess losses in different post harvest operations of safflower in Maharashtra State, one of the leading producers of safflower in India. Table 7.2 shows these losses. Traditional harvesting of safflower at about 9 and 10.5 percent grain moisture results in shattering losses of 1.25 and 0.31 percent respectively. The threshing operation by manual methods accounts for 1.25 percent losses. No drying operation is required as the crop is harvested in dry season when it is overdried. Storage in metallic bin yields no losses while gunny bags result in 1.0 percent loss. Total losses to the tune of 4.09 percent are recorded which are due to the fact that farmers are not aware of proper moisture levels for harvesting, threshing and storage.

7.2 Optimum Harvesting Time for Better Post Harvest Characteristics.

As per studies conducted at CIAE, Bhopal, it is observed that grain yield and oil content of JSF-1 variety of safflower significantly

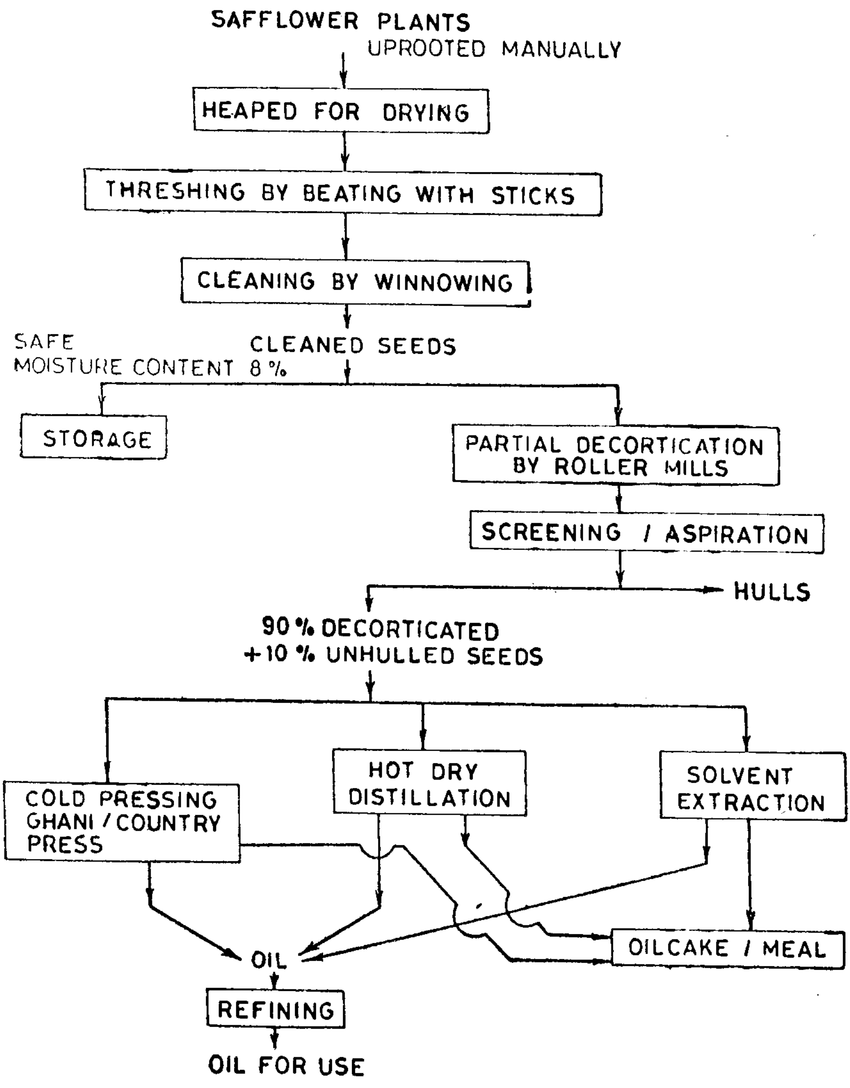


Fig. 7.1 Process Chart of Safflower Processing

Table 7.2 : Post harvest losses in safflower.

Sl. No.	Unit Operation	Losses, %	
		Range	Average
1.	Harvesting (Shattering losses)	0.31—1.25	0.78
2.	Threshing/Winnowing		
	Mechanical -	—	—
	Tractor	—	—
	Bullock	—	—
	Manual	0.58—1.03	0.81
3.	Sundrying	No drying practiced as the crop is harvested in dry season / condition.	
4.	Storage	—	—
	at farmers level	1.00	1.00
	at ware house	0.01	0.01
5.	Handling at farmers level		
	(a) from field to threshing floor	0.23—0.37	0.22
	(b) threshing floor to market/ storage	0.26—0 64	0.33
6.	Transport by tractor	—	—
7.	Handling at warehouse	0 20—0.40	0.30
8.	Milling losses	—	0.64
		Total :	4.09%

Source : All India Coordinated ICAR Scheme for Studies on Harvest and Post Harvest Technology-Annual Report of PKV-Akola Centre, 1986.

increases by nitrogen application upto 60 kg/ha level (of Nitrogen) and not beyond. The most optimum period for harvesting this variety is between 145 to 155 days after sowing, when the seed attains moisture content of 13 to 17.5 per cent However, protein and oil content of the seed significantly increase by delaying the harvesting date upto 160 days after sowing. Early harvesting by 10 to 15 days than the optimum dates, reduces the seed yield by 21.78 and 11 percent respectively while delayed harvesting by 5 days reduces the yield by 4.8. percent.

7.3 Threshing

For threshing of Safflower and other oil seeds, multi crop thresher developed at CIAE, Bhopal could be used. The performance of this multi-crop thresher was evaluated for threshing of safflower crop at two feeding rates and results were compared with the performance of a conventional spike tooth cylinder type of thresher. Table 7.3 presents the comparative performance of these two threshers for JSF-1 variety having 7.3 percent moisture content. From the results presented in this table, it is evident that the grain breakage and threshing efficiency of both threshers were almost comparable. However, the cleaning efficiency of local conventional thresher is low.

Table 7.3 : Comparative performance of threshers for safflower.

Sl. No.	Description	CIAE Multi-crop thresher	Local/Conventional spike tooth thresher
1.	Crop variety	JSF-1	JSF-1
2.	Straw moisture content, %	5.8	5.8
3	Grain moisture content, %	7.3	7.3
4.	Labour requirement	3 persons	3 persons
5.	Cylinder speed, rpm	530	525
6.	Blower speed, rpm	700	525
7.	Feed rate, kg/h	300-357	—
8.	Power requirement	1.52 to 3.16 KW	5 hp electric motor
9.	Broken grain, %	0.02	1.16
10.	Blown grain, %	3.01	0.23
11.	Spilled grain, %	0.11	0.13
12.	Total losses	3.14	1.52
13.	Threshing efficiency, %	100	100
14.	Cleaning efficiency	96.6	59.8

Source : All India Coordinated Research Scheme on Farm Implements and Machinery. Annual Report-1987, CIAE, Bhopal.

7.4 Cleaning and Grading

The pedal-cum-power operated air screen grain cleaner developed at CIAE, Bhopal could be used for cleaning safflower at farmer/processors level. Table 7.4 presents the specifications and test results of the cleaners with 6.5 mm sieve for scalper and 2 × 20 mm for grader.

Table 7.4 : Test results of air screen seed cleaners

Specifications/Test Parameters	Pedal operated cleaner	Power operated cleaner
Capacity, kg/h	274.0	315.0
Purity, %	98.7	98.5
Screen effectiveness, %	77.2	65.4
Cost of operation, Rs/t	40.0	40.0

7.5 Drying

Usually safflower is harvested at 5% moisture level hence no drying is required. However if it is harvested at higher moisture level, sundrying is recomonded. For this grain is spread over a 'Pacca' surface or black polyethylene sheet. The bed thickness is kept 30-40 mm. Mixing at 30 minutes interval during drying fastens the drying rate.

7.6 Storage

Studies conducted at PKV, Akola have shown that storage of safflower seeds show no deterioration and insect infestation during four months in glass and tin containers and plastic bags. As far as storage of oil is concerned, it is reported that glass containers at room temperature give better performance for 120 days storage of oil after extraction.

Studies have been conducted by JNKVV, Jabalpur also for storage of safflower seeds in 3 types of storage structures namely, baked earthen pitcher, gunny bag and plastic containers. Figures 7.2, 7.3 and 7.4 show the effect of storage periods of 0–120 days on oil, free

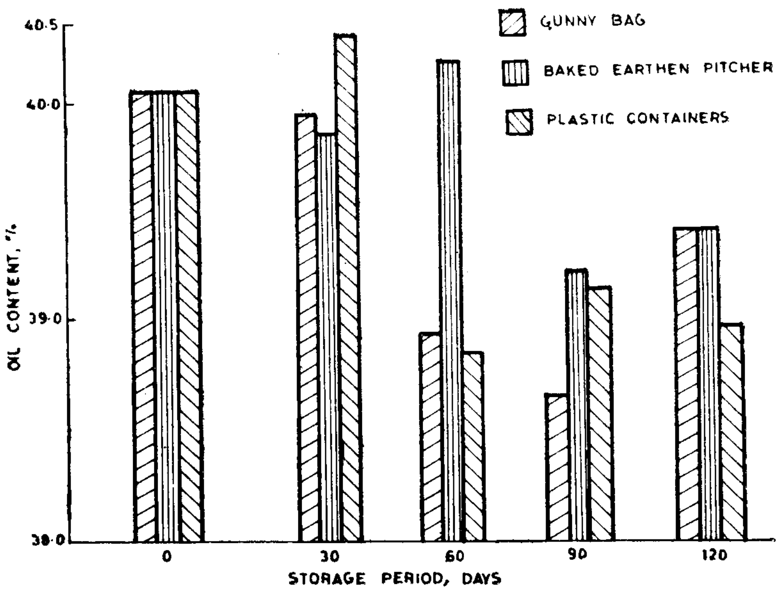


Fig. 7.2 Effect of Storage Period and Storage Structures on Oil Content of Safflower Seed

fatty acid and protein contents of safflower seed stored in these three structures. Insignificant variation took place in oil content which varied from 38.21 to 40.2 percent in gunny bag storage, from 39.1 to 40.0 percent in baked earthen pitcher and from 39.0 to 40.5 percent in plastic container. The slight decrease in oil content as compared to control might be due to oxidation of oil and loss of weight during storage period. The free fatty acid content varied from 1.1 to 3.1 percent in gunny bag, from 1.1 to 4.5 percent in earthen pitcher and from 1.1 to 4.6 percent in plastic container. Non significant difference was observed in protein content also with respect to storage period, moisture level and rheir interaction. It ranged from 16 to 16.75, 16 to 16.89 and 16 to 17.01 percent in gunny bag, earthen pitcher and plastic container respectively. The air tight and moisture proof plastic container was found to be better as compared to baked earthen pitcher and guuny bag for storage of safflower.

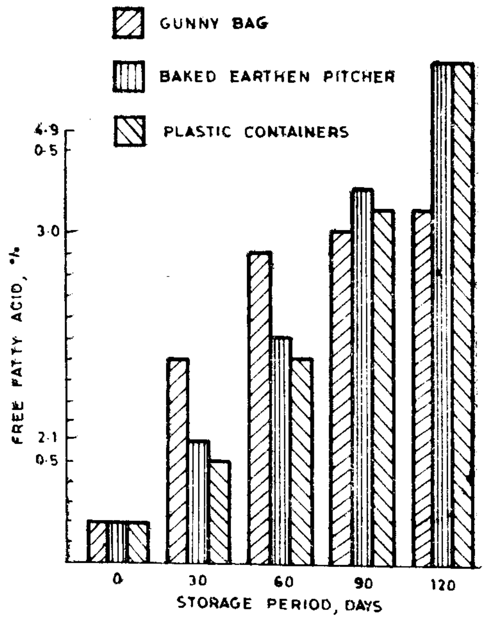


Fig. 7.3 Free Fatty Acid Content in Safflower Oil Seed in the Different Storage Containers

7.7 Dehulling

The hulls constitute a major fraction in safflower seed and hence its removal would affect the chemical composition of safflower meal. The yield of different fractions varies significantly from equipment to equipment as shown in Table 7.5 (Kulkarni et. al. 1988).

Table 7.5 : Percent dehulling fractions by different dehulling equipment.

Equipment	Head kernel, %	Hull, %	Brokan, %	Whole Seed, %	Losses, %
Rice sheller	36.96	21.10	16.60	20.16	5.18
Disc grinder	42.36	21.40	12.63	20.00	3.61
Plate grinder	40.66	20.26	20.20	15.33	3.55
Centrifugal sheller	36.63	15.73	10.30	34.03	3.31

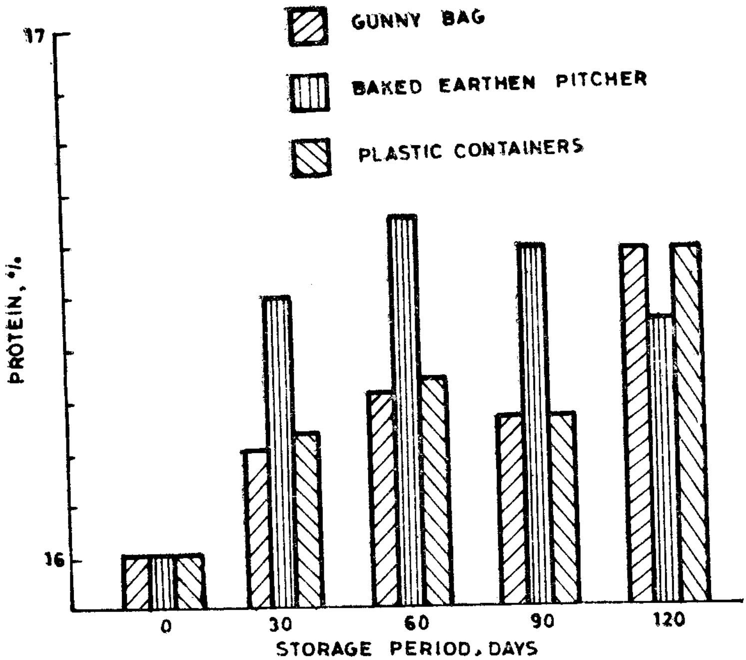


Fig. 7.4 Protein Content in Safflower in the Different Storage Containers

OTRI, Anantpur has developed a disc dehuller for safflower with steel discs. One of the discs is static and the other rotates at a speed of 600 rpm by a 15 Hp motor. The clearence between the discs can be varied. A shaker separator with suitable mesh screens and a cyclone separator are synchronized with the machine to get a continuous performance. Under optimum conditions of the moisture content of seed and clearence between the discs and spead, the yield of hull fraction is 34-38% containing 86-99% pure hulls. The cost of the machine is approximately Rs. 25,000.

OTRI, Anantpur has also developed a low cost grinder dehuller for safflowr seeds. This equipment with a cost of about Rs. 3,000/- consists of two grinding stones one on the top of the other. The top stone revolves horizontally by a shaft and pulley arrangement driven by a 5 Hp motor. There is provision for feeding at the centre of grinding stones. The dehulled seed comes out of the spout provided at the side. However, separate arrangements have to be made for the separation of hulls. The capacity of the machine is 3-5 t/d.

The multi-purpose grain mill developed at CIAE, Bhopal (Fig. 5.18) has been found suitable for decortication of safflower. The specifications and test results of this equipment are given below :

Overall dimensions	:	700×500×700 mm
Type	:	Vertical stone burr grinder
Total weight	:	69 kg with motor
Capacity	:	75 kg/h
Decoritication efficiency	:	90-95% (at 5-9% m. c. of seed)
Power requirement	:	1 HP electric motor
Cost of equipment	:	Rs. 3,500 (approx.)

CIAE, Bhopal has also developed a multioilseed decorticator which gives a capacity of 90 kg/h with 60-70% decortication efficiency. The details of the equipment are given in chapter 8.

7.8 Oil Extraction

Studies have been conducted at OTRI, Anantpur for developing processing technology of safflower It was observed that there is not much difficulty in the case of either whole or ground seed crushing with all the hull content but as the percentage of hull decreases, it presents difficulties in the formation of normal cake as the whole material becomes a mash in the cooker itself and the expeller does not accept the pasty mass. To aid the formation of cake, small quantities of binding agents viz Gaur gum. gum arabic and tamarind proved ineffective while addition of even one percent jaggery considerably enhanced the case with which the crushing could be accomplished (Table 7.6). During these experiments, it was found that certain changes in the cooking conditions can do away with the use of these addivities altogether and the proportion of hulls required for easy and efficient crushing can also be reduced to as low as four percent in the field.

Table 7.6 : Composition of feed meats and yield of products after screw-pressing safflower

S. No.	Additive	Hulls, %	Oil content, %	Oil, %	Cake, %
			Composition of feed weiht basis	Yield of feed	
1.	Whole seed	48	30.4	22.6	73.4
2.	Ground seed	48	28.9	22.3	73.1
3.	No additive	34	38.2	32.2	59.9
4.	No additive	29	42.7	34.0	55.8
5.	3% jaggery powder	29	—	39 9	60.6
6.	2% jaggery powder	27	41.8	35.3	57.9
7.	2% jaggery powder	24	44.1	37.5	56.6
8.	2% gum arabic + 3% jaggery	24	—	34.9	58.5
9.	1% jaggery powder	19	—	39.9	54.2
10.	3% jaggery + 3% water	13	—	44.6	50.8
11.	No additive	5	50.1	44.8	48.8
12.	No additive	4	51.6	44.5	48.5

Moisture in the feed was about 6 percent.

Source : Lakshminarayana et. al. (OTRI) Anantpur

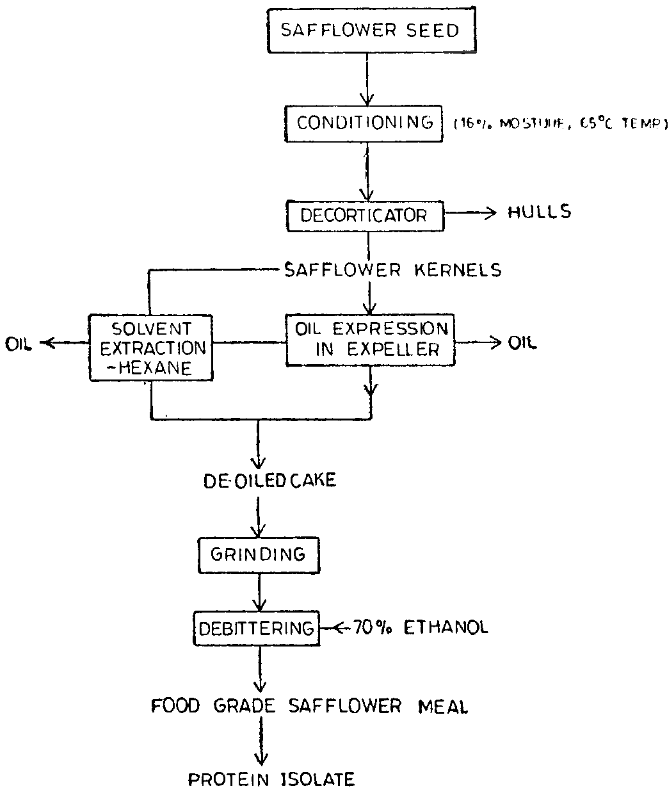
The feed has been found to become mash in the cooker under certain conditions generally followed in the case of groundnut and cottonseed, that is, cooking for 30-45 minutes over 100°C. The runs in which addition of binding agents was necessary were made applying the above cooking conditions. The modified conditions of cooking applicable to the pure safflower meats are : the feed at a moisture level of about six percent should mildly be cooked below 100°C with live steam for about 10 minutes before it is allowed into the cage of the expeller and the meats should be hot, free-flowing hard and not become pasty when pressed in hand but should remain discrete. To achieve these conditions, the feeding of material into the cooker and feeding of cooked material into screwpress cage was suitably adjusted.

Employing this method of cooking and crushing pure meats containing not more than five percent hulls, a cake of over 50 percent protein content was obtained. The load on the expeller was reduced and its capacity increased. The extraction efficiency was also high. The extraction efficiency in the case of whole seed crushing was 74 percent as compared to 89 percent in the case of meats (with five percent hulls) crushing. From 1,000 kg of seed, 67 kg of oil was left in the cake from whole seed crushing, 59 kgs of oil from ground seed crushing and only 20 kg of oil from pure meats crushing. The protein contents of cake was higher varying from 30.8 to 54.5 percent depending on the hull content of the meats crushed. It may also be noted that in the case of crushing pure meats, about 1.5 percent more yield of oil was obtained than in the ease of whole seed or ground seed crushing. There was not much difference in the quality of the oil obtained in the three runs.

Preliminary studies conducted at CIAE, Bhopal for extraction of safflower oil with the help of a table oil expeller have shown that mixing 50% decorticated and 50% undecorticated seed, the expeller yields 81% of oil in two passes at 9.4% moisture content. The capacity of the expeller was 12–15 kg/h with energy requirement of 0.718 KW/Kg seed.

7.9 Production of Edible Grade Meal

Studies have been conducted at MAU, Parbhani to produce edible grade meal from safflower. Safflower seeds of N-62-8 variety were given a conditioning treatment during which the temperature of seeds was increased to 65°C and seeds were passed through emery rollers and kernels were separated from the hulls. The kernels were used for expressing the oil by expeller and deoiled cake was solvent extracted and grinded to get 75 micron size flour, wet protein isolate was prepared by dissolving safflower protein in water at 9 pH. The slurry was acidified to get pH level of 4 to precipitate proteins which were latter filtered. The conditioning of safflower at 65° was reported to help in loosening the hulls from kernel and the breakage of kernels and admixture of hulls in the kernel was also minimized. This also helped to reduce total fibre content of oilseeds cake to minimum level and the cake was suitable for being incorporated in other food stuffs. Figure 7.5 shows the flow process chart for preporation of food grade kernel from solvent extracted meal while Table 7.7 shows the chemical composition of whole seed, kernel and deoiled and solvent extracted cakes. The deoiled cake and solvent extracted cake contain 56.3 and 64.2 percent proteinr espectively which could be fortified with other food preparations. The meal could be used for isolation of protein. It was observed that 85 to 90 percent protein could be



Fi5. 7.5 Process Flow Diagram for Production of Edible Grade Meal from Safflower

Source : Kulkarni et. al. 1984

stabilized at pH level of 9 an most of the protein gets precipitated at 4 pH level. The soluble and insoluble carbohydrates could be separated by centrifugation. The bitter flavour of cake or meal and protein isolate could be eliminated by extraction of meal with aquosus ethanol.

Table 7.7 : Composition of safflower seed, kernel, deoiled cake and solvent extracted cake (% dry weight basis)

Sl. No.	Product	Composition, %			
		Crude protein (N × 6.25)	Crude fat	Crude fibre	Ash
1.	Safflower seed	17.8	34.4	20.0	2.1
2.	Kernels	27.2	61.0	1.0	2.6
3.	Deoiled cake	56.3	13.1	2.9	4.2
4.	Solvent extracted cake	64.3	2.0	3.8	6.5

Source : Kulkarni et. al. 1984

The major problems in the utilization of safflower meal for edible purpose are the presence of high fibre in meal and a strong bitter flavour which can be reduced by dehulling of the seeds and pretreating the meal. The removal of hulls affects the chemical composition of the safflower meal. Chemical composition of unhulled and dehulled oilseed meals on ghani crushing and solvent extraction is given in Table 7 8. The effect of dehulling is highly significant on reducing crude fibre content in ghani pressed and solvent extracted meal. The removal of crude fibre and extraction of oil by crushing as well as solvent extraction caused a significant increase in protein of the dehulled meal. Studies conducted at MAU, Prabhani have resulted in production of meal containing less than 5% crude fibre and is thus suitable for development of high protein food products. Table 7.9 gives the effects of debittering treatment on crude fibre, crude fat, crude protein and ash (Kulkarni et. al. 1988).

Table 7.8 : Effect of dehulling on chemical composition of safflower meal (% dry wt. basis).

Sl. No.	Samples	Crude prot. N x 6.25	Crude fat, %	Crude fibre, %	Ash, %
1.	Undehulled ghani crushed safflower meal.	41.6	12.5	16.6	6.6
2.	Undehulled solvent extracted safflower meal.	54.2	2.0	19.6	7.2
3.	Dehulled ghani crushed safflower meal	55.4	13.2	3.9	4.2
4.	Dehulled solvent extracted safflower meal.	59.9	2.1	4.3	5.9
5.	Dehulled solvent extracted and sieved safflower meal.	62.2	2.1	3.8	6.5

Source : Kulkarni et. al. 1988.

Table 7.9 : Effect of debittering treatment on chemical composittion of safflower meal and protein isolate (% dry wt. basis)

	Samples	Crude prot. N x 6.25	Crude fat, %	Crude fibre, %	Ash, %
1.	Untreated	64.2	2.0	3.86	6.5
2.	70% Ethanol treated meal	64.1	1.1	3.96	7.1
3.	80% EtOH treated meal	63.1	1.1	3.90	7.0
4.	96% EtOH treated meal	63.8	1.0	3.92	7.1
5.	80% Isopropanol treated meal	63.5	1.0	3.96	7.1
6.	Absolute isopropanol treated meal	63.8	1.1	3.91	7.0
7.	Water extracted meal	65.7	1.9	3.91	7.3
8.	Dialysed meal	65.9	1.8	1.95	7.3
9.	B-Glucosidase treated meal	64.3	1.9	3.95	7.3
10.	Safflower protein isolate	93.2	0.3	Nil	1.9
11.	Dialysed protein isolate	94.1	0.3	Nil	2.1
12.	B-glucosidase treatee protein isolate	39.6	0.3	Nil	2.0

Source : Kulkarni et. al. 1988.

8. SUNFLOWER

Sunflower *(Helianthus annus L.)* is one of the oldest native crops of North-America, grown and cultivated as a food crop by North-American Indian tribes as early as 2000-3000 BC (Puff. 1978). It was introduced in Europe by Spanish explorers returning from this continent in the early of 1500 A. D. By 1800 A. D., it was extensively grown as an oilseeds crop in Russia. In U.S.A. and Canada, however, it was re-introduced by a few seed companies and immigrants came to these countries and by 1950's, it was grown commercially. In the mid 1960's a new high oil yielding sunflower variety 'Peredovik', developed in U. S. S. R. was introduced into U. S. A. It was an open pollinated, thin hulled high oil (40-45%) content variety. The work of Russian scientists has contributed significantly to the increase of its very high oil content from 25-30% in post-world War II period. In India, though sunflower was known as an ornamental plant for quite some time, its cultivation as source of oil has started only in seventies. Its acceptance in India could be judged from its cultivation area which has drastically increased from mere 0.69 lakh ha in 1979-80 to about 10.5 lakh ha in 1989-88 having total producting of 0.5 million tonnes of seed.

Sunflower is a robust oilseed crop, the seeds of whish contain about 20% protein in addition to 40-50%, oil which has a mild taste, pleasent flavour, good keeping quality with acceptable amounts of vitamins A, D and E. It has a low seed rate, short duration of 60-90 days, adaptable to different soil conditions and can be grown even under saline conditions. It has a deep tap root with extensive lateral root branching and is capable of removing moisture from a deep soil profile. Under dry land farming, medium and moderately textured soils with moderate to good internal drainage are better suited for sunflower. The plant grows luxriantly udder irrigated conditions but gives a fair degree of performarce under stress conditions too. It can be grown satisfactorily as a kharif crops in areas where rainfall is 20 cm or more in one or two months out of a total of 4 rainy months of June to September. However, being photo-intensive crop, it can be grown throughout the year. It has an excellent drought tolerant capacity and under dryland conditions, its returns are comparatively high than the other dryland crops The crop performs excellently in the mixed cultivation with maize, bajra, castor and cotton and the yields go up when it follows a legume crop.

This Chapter presents the state of art of sunflower processing, R & D studies on threshing, cleaning and grading, oil expression, storage technology of sunflower as well as reports about various equipment developed in India and abroad for carrying out these operations.

8.1 Present Status of Sunflower Seed Processing

After sunflower comese to maturity, it is left in the fields until the colour of the back of its head changes from green to yellow and seeds become loose. The heads are cut either before the seeds are quite ripe to avoid shattering losses or the whole plant is uprooted and heads cut off with a sickle, knife or clippers and exposed face up between rows to dry. When they are thoroughly dried, the heads are threshed by placing them on racks or thev are piled face downwards on floor and beaten with flails. The heads are often rubbed face downwards over a metal piece fixed in a wooden frame or are gently pressed against revolving cylinders studded with nails. Threshed seeds are spread out in a thin layer on a dry airy floor and turned over occasionally until they are dried, The seeds are cleaned and dry florets and other light impurities are removed by winnowing. Dry seeds keep well for a number of years and retain their viability if stored in a dry and cool place. However rapid rise in temperature has been observed in piles of seed, especially if the moisture content exceeds 12%. Seed has a hard woody pericorp and kernel constituting 60·65% of the whole seed. The oil content of seed ranges from 22 to 40 percent. Oil is usually extracted by cold pressing of dehulled seeds followed by hot pressing in hydraulic presses in Russia while it is mostly solvent extracted in Yugoslovia. The average yield of oil is 22 to 30%. Refining losses are low. The crude sunflower oil is of light amber colour with a mild taste and a pleasent flavour. The refined oil is pale yellow and has good keeping quality with little tendency for flavour reversion. The oil contains appreciable quantity of vitamins A,D and E.

The residual meal, left after oil extraction is used as a high grade protein supplement for livestock, especially dairy cows and poultry. This meal is also used as a nitrogenous fertilizer. The seed heads and stalks could be used as a dry season fooder while hulls are good source of fuel for use in furnaces.

8.2 Thresing

Threshing of seed heads is an important unit operation which consists ot two steps : (i) dislodging of the seeds from the ear head and (ii) separation of seeds from florets, chaffy and other plant materials. The methods in vogue for threshing sunflower are (a) beating the seed heads with flails and winnowing the seeds, (b) rubbing individual seed heads manually against a rough surtace or moving wire mesh netting, (c) spreading seed heads on the floor, rolling on them stone rollers drawn by bullocks and winnowing the seeds, (d) using rasp bar type grain threshers or maiz sheller after some modification in these equipment.

Studies conducted at UAS, Bangalore with three types of threshing methods viz. rasp bar type and disc type threshers and hand threshing at various moisture levels have been shown that at m. c. of 10.5%, the threshing by rasp bar type thresher gives maximum outturn of 342 kg/h with a threshing efficiency of 98% and is more economical compared to disc thresher or hand threshing. However, disc and hand threshing may be used by small and medium farmers and the threshed seed may be used for breeder seeds because of very low (1.5%) breakage and high germination (88% to 89%). The specification of rasp bar and disc threshers are given below :

Rasp bar type thresher

Type of drum	:	Octogonal
Length of drum, cm	:	42
Width of rasp, bar, cm	:	7

Length of rasp bar, cm	:	42
Clearance, cm	:	2
Speed of the drum, cm/min	:	41
Speed of rasp bars, m/min	:	81
Speed of the blower, rpm	:	850
Power requirement, HP	:	5

Disc type thresher

Diameter of the disc, cm	:	29
Length of pin, cm	:	1.5
Diameter of the pin, mm	:	4
Speed of the rotating disc, m/min.	:	40
Power requirement, HP	:	1

UAS, Bangalore has developed a foot operated thresher (Fig. 8.1) which could be also operated by a 0.5 HP electric motor. Two persons are required for threshing sunflower earheads. The equipment has a capacity of 45 kg/h. The OTRI, Anantpur has developed a sunflower thresher after incorporating the following modifications in commercially available 'Kalyan' groundnut decorticators : (i) the spacing between edges in the trough-like grate is adjusted to 20-25 mm, (ii) the blower rpm is adjusted at 220 and (iii) the lower half of the inclined plane is perforated with 10-13 mm round holes. Fig. 8.2 shows the developed thresher.

The capacity of the thresher is 3-4 t earheads/d (24 h) with almost 100% deseeding efficiency. The OTRI, Anantpur has also developed a continuous moving belt manual thresher for sunflower which consists of a moving belt made of rough coir mat or mild steel wire mesh. The machine is fitted with a motor and blower/fan. The dimensions of the machine are 1100 mm length and 6000 mm width. The capacity of the machine is 200 kg sunflower earheads/d with 35% bold seed, 15% spurious seed and chaffy material and 50% diseased heads. The cost of the machine is about Rs. 5000/-.

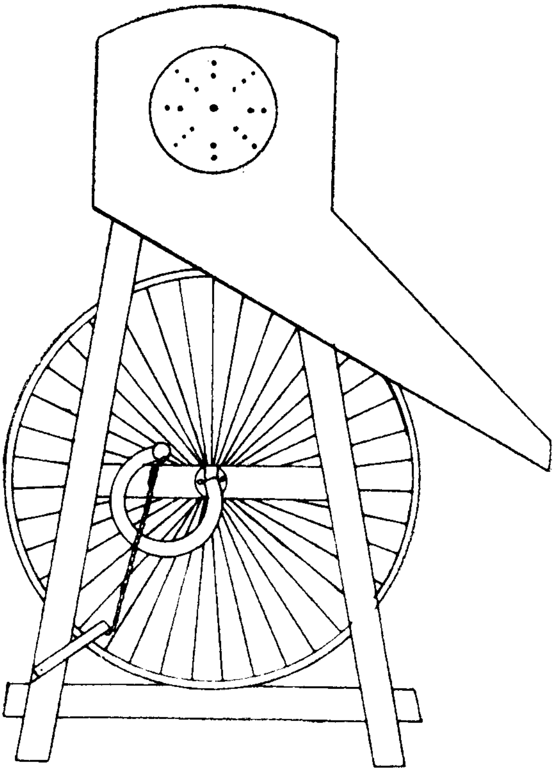


Fig. 8.1 Foot Operated Sunflower Thresher

A sunflower thresher has also been designed, developed and evaluated at Agril. Engg. Res. Centre, College of Agriculture, Pune. The thresher, shown in Fig. 8.3 is a 'hold-in' type, pedal operated, light weight-low cost machine. The threshing and cleaning efficiencies are respectively 100 and 96-98%. The output capacity of the machine is about 40 kg seed/h and cost of equipment is approximately Rs. 1,000/-.

The multi-crop thresher, developed at CIAE, Bhopal has an output capacity of 170 kg/h with feed rate of 462 kg/h at 340 rpm of the threshing drum. Threshing efficiency of 100% and cleaning efficiency of 89.8% is attained with 4.41% broken grain, 2.67% blown grain and 0.63% spilled grain.

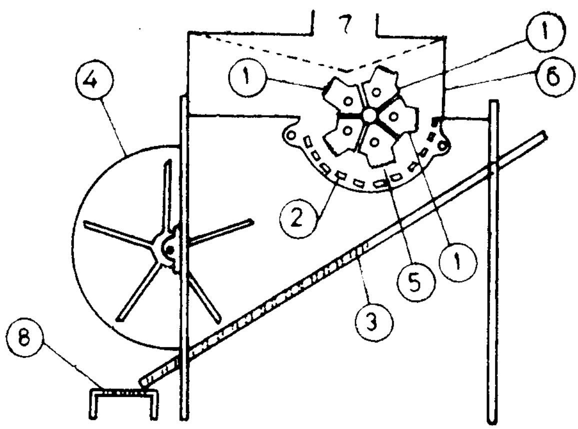


Fig. 8.2 Sunflower Thresher

1. Beater 2. Trough-Like Grate 3. Half Perforated Inclined Plane 4. Fan Blower 5. Spacings 6. Cover 7. Hopper 8. Perforated Stand

The OTRI, Anantpur is also reported to have developed a semi-mechanical thresher which threshes 1000 kg sunflower seed in 24 hours. The LTC theresher, meant for paddy and sorghum crops, gives an output of 10 kg/h with 90% tnreshing efficiency at 16% seed moisture content with no breakage as reported by TNAU, Coimbatore.

8 3 Drying

The sunflower seeds are dried below critical moisture content of 7-9%. Studies conducted in USA have indicated that oil content has almost no effect on drying rate. Common drying chambers may be used for this purpose at appropriate temperature and for necessary duration of the drying, without violating the internal balance of the seed. The temperature should not be too high and drying could be done by contact, convection or radiation drying. In case contact drying is done, the seeds need to be conditioned prior to oil expression. A drying air temperature of 110°C or grain temperature of 51°C is recommended in case of heated air drying, while a steam temperature of 130°C is recommended at 4-5 kg/cm^2 saturated steam pressure in case of steam drying.

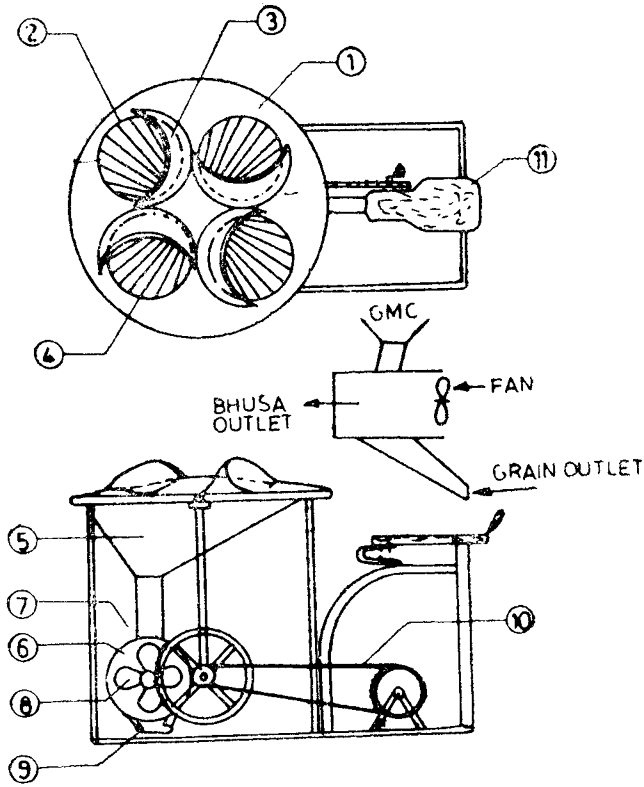


Fig. 8.3 Phule Sunflower Thresher

1. Top Cover 2. Feeding Hole 3. Cap 4. Threshing Wheel
5. Grain Mixture Collector 6. Sepration Passage 7. Bhusa Outlet
8. Fan 9. Grain Outlet 10. Power Transmission 11. Seat

TNAU, Coimbatore has developed a solar drier which has been found suitable for drying of sunflower earheads. The specifications are the following :

Type	:	Flat plate absorber
Capacity	:	500 kg/batch
Power requirement for blower	:	3 H. P.
Cost of equipment	:	Rs. 15,000/-
Suitability for crops	:	Paddy, groundnut and sunflower earheads

The drier consists of a flat plate collector, suction blower and grain holding bin. The drier requires 90 minutes for reducing moisture content of sunflowar earheads from 32 to 14% at hot air temperature of 34 to 56°C with a bed thickness of 35 mm.

8.4 Cleaning and Grading

The pedal-cum-power operated air screen grain cleaners developed at CIAE, Bhopal for cleaning of oilseeds with sieves of 8 mm for scalper and 3 mm for grader can be used for sunflower with a capacity of 280-350 kg/h and 96-91% purlty.

8.5 Decortication

Hull content of sunflower seeds varies between 30-40% depending on the variety. Its hull mostly contains crude fibre and insignificant quantity of fat. It is usually removed before oil extraction otherwise its presenee would cause great wear on machinery with higher energy requirement as well as its presence in cake or meal would reduce their biological value. Moreover, the hull would reduce the total yield of oil by absorbing and retaining oil in the pressed cake, hence its removal is must. Traditionally the hull of sunflower seed is removed by hand. The flattened shape of sunflower seed presents an inherent difficulty for complete dehulling of the seed using a disc huller as considerable proportion of seed escapes undecorticated. The studies conducted at OTRI, Anantpur for decorticating sunflower seed in a Bauer disc huller fitted with a plane emery disc with shaker and cyclone separator gave following results.

Yield of coarse meats	:	70%
Fine meats	:	13%
Free hulls	:	17%
Proportion of uncut seed in the coarse meat after one recycling of meats over shaker separator	:	20%

The OTRI, Anantpur has also developed a disc huller for sunflower which is made of emery discs. One of the disc is static and the other rotates at a speed of 600 rpm by a 15 HP electric motor. The clearence between the discs can be varied. A shaker separator with suitable mesh screen and a cyclone separator are synchronized with the machine to get a continuous performance. The capacity of the machine is 8 t-seed/d and under optimum conditions, coarse meats of 70%, fine meats of 11.5% and hulls of 17.5% yields are obtained. The cost of the machine is about Rs. 60,000/-

The Tropical Product Institute, U.K. has developed a hand operated bar and disc mill of 7-20 kg/h capacity for decortion of sunflower. Figures 8.4 and 8.5 show these equipment. Bar mill is suitable for decortication of high oil content seed while disc mill is used for decortcation of low oil bearing or confectionary type sunflowar seeds

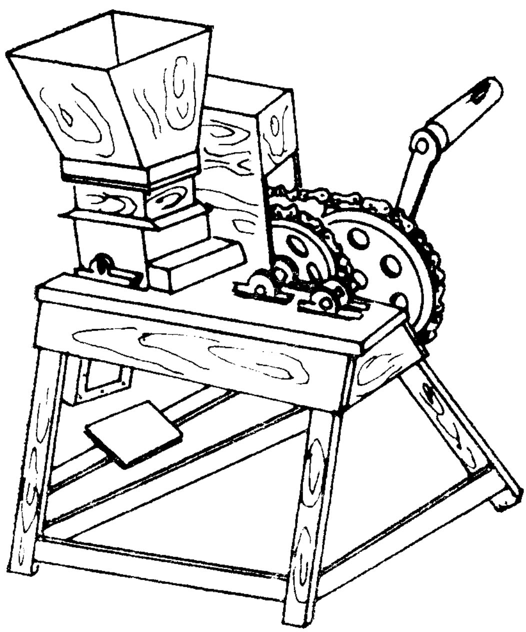


Fig. 8.4 Hand Operated Bar Mill for decorticating Sunflower Seed

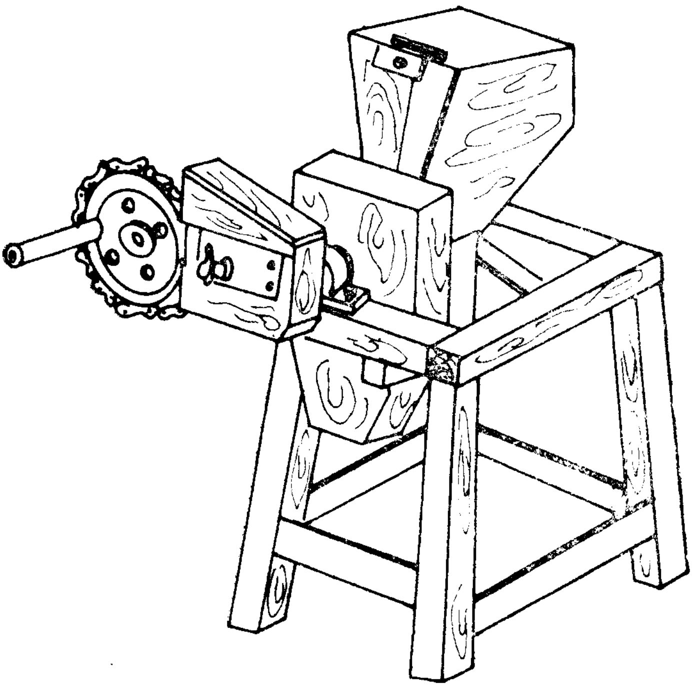


Fig. 8.5 Hand Operated Disc Mill for Decorticating Sunflower Seed

CIAE, Bhopal has modified its manually operated groundnut decorticator for sunflower by changing the oscillator with a rubber lined shoe and sieve. The modified decorticator (Fig. 8.6) gives a capacity of 12 kg/h with 49% heed yield, 22% hull, 6% broken and 23% undecorticated seed. Based on the design concept of hand operated sunflower seed decorticator, developed at TPI, U. K. a power operated multi-oilseed decorticator has also been developed at CIAE, Bhopal. The equipment, shown in Fig. 8.7, consits mainly of a high speed fluted rotor, stator, hopper, blower and sieve assembly. Rotar, made of mild steel has 200 mm length and 100 mm diameter. Stator is also made of mild steel with a 200 mm length and half-breadth diameter of 45 mm. Fluted rollers have been provided in hopper for uniform feeding of the seed. An arrangement has also been provided for separation of hull, kernel and undecorticated seed. Decortication takes place due to abrasive and shearing action between stator and rotar. The equipment gave following test results :

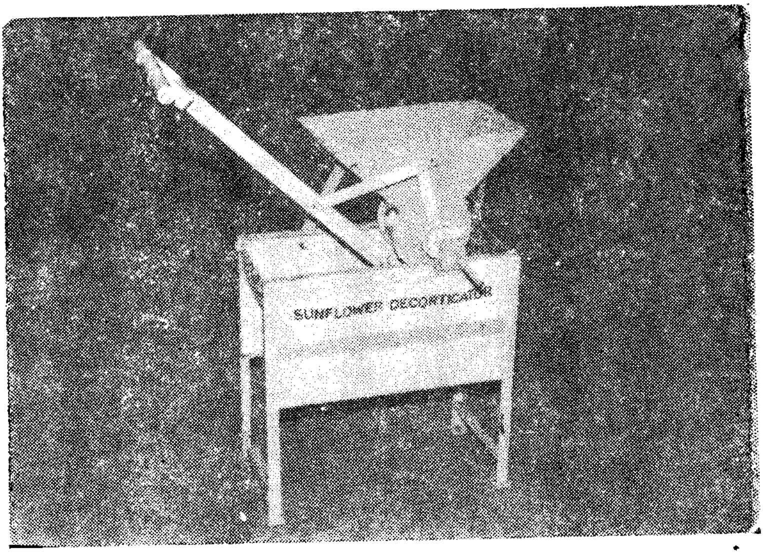


Fig. 8.6 Hand Operated Sunflower Decorticator (Side View)

Suitability	:	Decortication of sunflower, safflower, and castor seeds and dehulling/splitting of soybean seeds.
Capacity	:	40 kg/h sunflower, 60 kg/h safflower, 40 kg/h castor and 80 kg/h soybean
Decortication efficiency	:	95–98% (70% for safflower)
Main product recovery	:	65-70%
Seed damage	:	2–4%
Power requirement	:	0.5 HP electric motor
Labour requirement	:	One person
Cost of equipment	:	Rs. 5,000/-

College of Technology and Agricultural Engineering, RAU, Udaipur has also developed a centrifugal impeller type decorticator for sunflower. The machine, shown in Fig. 8.8 consists of hopper, centrifugal impeller, casing, collecting chute and tranmission system. Decortication is achieved by subjecting the seeds at high centrifugal force and then striking them on a hard surface. The performance of

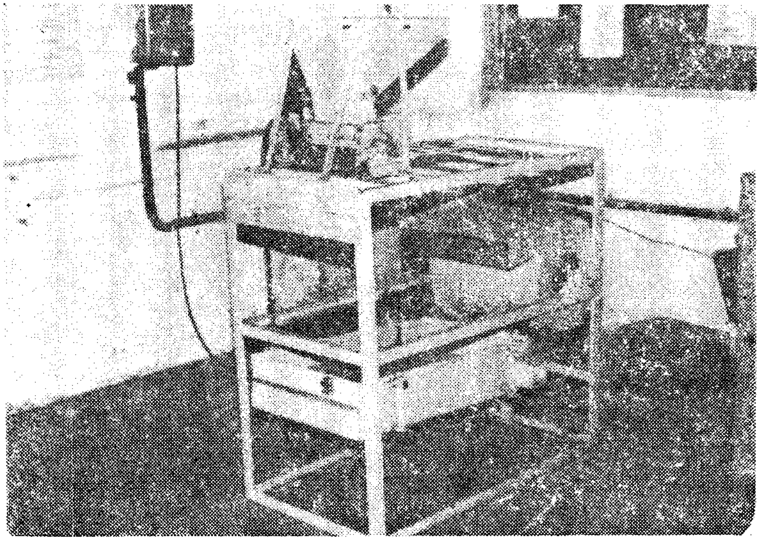


Fig. 8.7 Power Operated Multi-Oilseeds Decorticator

this machine was evaluated at different moisture content levels of the seeds and feed rates and peripherial speeds of the impeller. The decortication efficiency increased with decrease in the moisture content of the seeds. An increase of about 18% in efficiency by reducing moisture content from 12.2 to 6.7% at a feed rate of 120 kg/h and peripherial speed of 2900 m/min. or respectively 17 and 10% and the feed rates of 240 kg/h and 360 kg/h at similar moisture content was obtained. The efficiency decreased with an increase in feed rates of about 5% when the feed rate was increased from 120 kg/h to 340 kg/h at a peripherial speed of 2900 m/min. The efficiency increased almost proportionally with the speed; an increase of about 65% when the speed was changed from 1320 m/min to 2900 m/min at moisture content of 6.7% and feed rate of 120 kg/h. The optimum range of paripherial speed which gave high efficiency and less seed damage was between 2000 to 2600 m/min. (Nag. et. al. 1983).

TNAU, Coimbatore has developed a power operated sheller for sunflower which is also of centrifugal tyoe, consisting of a high speed

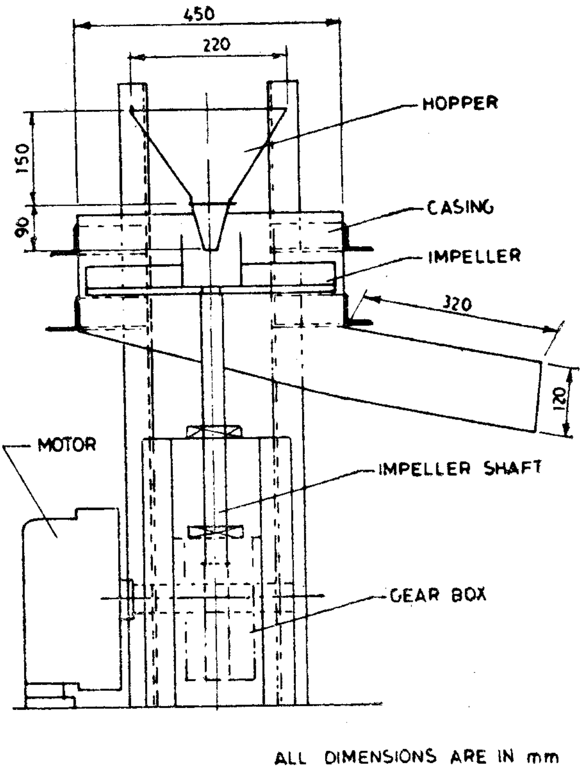


Fig. 8.8 Sunflower Seed Decorticator

rotar, rubber lined stator, blower, elevator and sieves. Shelling is done by impact. The equipment, shown in Fig. 8.9 is operated by a 3 HP electric motor and its capacity, and cost are 1.25 q/h and Rs. 10,000/- respectively. The equipment is commercially manufactured by M/s Hema Engg. Works, Coimbatore, India.

8.6 Oil Extraction/Expelling

Pierce (1970) has reported that decorticated sunflower seeds at 4.6% moisture content gave satisfactory results at 80-100°C barrel temperature of expellers. Studies conducted by Prinsloo and Hugo (1971) have shown that varying the choke setting of a small

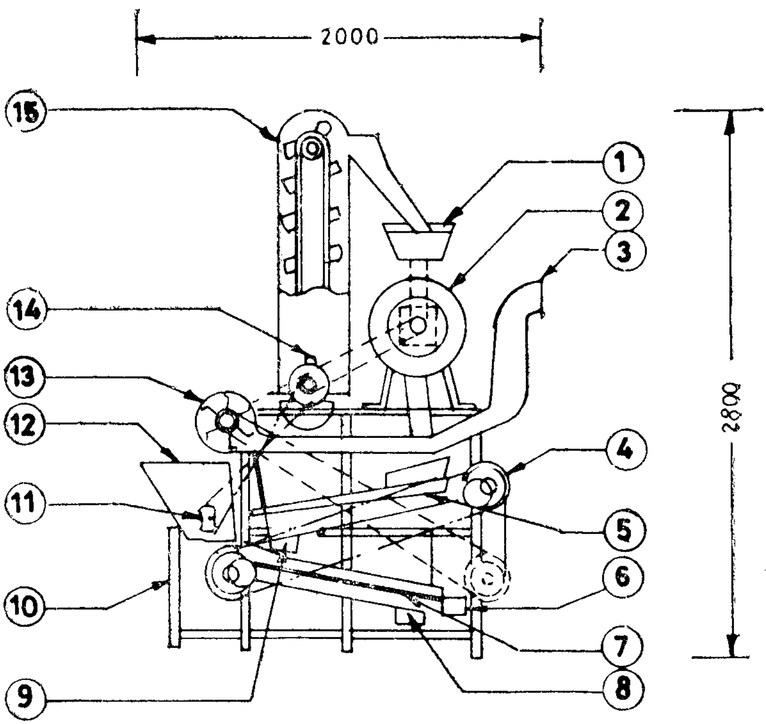


Fig. 8.9 Sunflower Seed Sheller

screw expeller for processing sunflower seed, changed the barrel temperature, meal oil content or oil extraction efficiency, the meal thickness and power consumption. Thompson and Peterson (1982) tested pre heating effects on oil extraction with a Cecoco Hander expeller with sunflower seed and found that oil out put decreased with an increase in pre-heat temperature. Jacobsen and Backer (1986) tested a Hander vegetable oil expeller (capacity 45 kg seed/h, powered by a 2.2 KW electric motor) for oil expression from sunflower. Expeller performance was reported to be effected by the qualities of sunflower seed. Pre-heating the seed had such a dramatic impact on expeller performance that the capacity and oil out put doubled. It was recommended that if high capacity and oil output from low moisture content sunflower seeds are desired, pre-heating would be necessary. However, if high efficiency is desired, low moisture content sunflower seeds and high expeller pressures are recommended.

Studies conducted at CFTRI, Mysore have indicated that seed pre-treatment by cleaning, grading and decortication, give rise to improved oil recovery, good quality oil free from wax and higher grade meal useful for food and feed purposes Similarly studies conducted at OTRI, Anantpur have shown that while crushing whole sunflower seeds in a screw expeller, setting worm reverse gives the maximum oil yields (upto 33%) in two crushings at 65-70°C temperature. However, the final oil content of expeller pressed sunflower cake was about 12%, considered to be a fairly high oil loss in the cake.

As per studies concucted at ORTI, Anantpur, oil yields from sunflower seed containing 43% oil by different crushing equipment and under different processing conditions are 21-31% by village ghanies, 25 to 27% by hydraulic press, 29% by baby expeller and 32% by standard expeller Table 8.1 shows the performance of these equipment. In ghani, crushing of whole seed gives an oil yield of 23% with 54% extraction efficiency. Dehulling improves the performance, oil yield being 28% (65% extraction efficiency). Effect of cooking is remarkable, increasing the oil yield to 31% (i. e. 72% extraction efficiency). In case of hydraulic press, the oil yield of about 25% (extraction efficiency of 59%) was observed. However, there was not much difference in oil yield by dehulling the seeds or its temperature being raised to 55-60°C during pressing. In case of baby expeller, cooked wholeseed crushing gave 29% oil yield with 67% extraction efficiency in a single pass adjusted to give maximum pressure. Standard expeller gave 32% oil recovery with 75% extraction efficiency in two crushings. Table 8.2 shows the quality of sunflower oil and cake obtained by above mentioned equipment. It may be seen that ghani oil was darker in colour and has relatively higher free fatty acids content, probably due to practice of sprinkling water in the feed while crushing. Cooking the kernels yielded oil with lower free fatty acid content. Hydraulic pressed oil are very light in colour and have low free fatty acids while expeller pressed oils are normal. The residual oil contents of cake show wide variations and are generally higher than desired.

In another study conducted at OTRI, Anantpur, following pre-parations were adopted for crushing sunflower seed : (a) Cooking and crushing wholeseed (b) rolling the whole seed through 'single pair smooth rolles, cooking and then crushing the cracked seeds and (c) dehulling the seed, cooking and crushing the meats.

Table 8.1 : Perormance of different crushing equipment for oil Recovery from sunflower

Seed/Pertreatment	Oil Yield,%			
	Ghani	Hydraulic press	Expeller	
			Baby	Standard
Whole Seed				
raw	23 (54)	25 (58)	—	—
Cooked	21 (49)	27 (63)	29* (67)	32++ (75)
Kernel				
raw	28 (65)	25.0 (58)	—	—
Cooked	31 (72)	25.5 (59)	—	—

Ghani : 10 kg/batch, hydraulic press : 1 kg/ batch, baby expeller 100 kg/ batch and standard expeller : 300 kg/ batch

* Single pressing, ++ Double pressing. Figures in parenthesis show the percentage extraction efficiencies.

Ref. : Ramchar et. al. 1975

Rose Down 'Max Oil' expeller was used for cooking and crushing sunflower seeds. The seed was crushed under conventional conditions i. e. cooking the meat with slight open steam for 15 minutes, maintaining 95–100°C temperature in the cooker. Three crushings were adopted, the results of which are presented in Table 8.3. It may be noted from this Table that wholeseed pressing as well as rolled seed pressing gave 32% oil yield. Rolling the seed carcks the seed and exposes the kernel, crushing of which is easier and higher yields are obtained in the 1st pressing than the corresponding 1st pressing of whole seed. Crushing dehulled seeds, gave 34% and 34.8% oil yields in two runs of expeller. The protein contents in final cakes obtained by whole seed pressing, rolled seed pressing and dehulled seed pressings were 32.2, 32.2 and 44%, respectively. The level of protein in sunflower cake by dehulling seed compared favourably with that of commercial groundnut cake. The free fatty acid content of oil was little over 1% and the oil was bright yellow in colour and of prime flavour (Khan et. al.).

Table 8.2 Quality of sunflower oil and cake obtained by various equipment

Mode of crushing	Pre-treatment	Oil			Cake	
		Colour in tintometer		FFA, %	Oil, %	Protein, %
		Y	R			
Ghani	Wholeseed					
	raw	42	1.0	6.6	24.0	25.0
	cooked	42	0.9	3.2	24.0	25.0
	Kernel					
	raw	42	0.9	4.1	17.6	40.0
	cooked	42	0.8	2.2	21.5	39.4
Hydraulic	Wholeseed					
press	Cold	8	0.6	0.5	21.2	—
	hot	9	0.7	0.3	19.3	—
	Kernel					
	raw	8	0.4	1.6	22.6	—
	cooked	8	0.6	2.8	22.1	—
Expeller						
Baby	Wholeseed	48	0.8	1.5	15.2	28.7
Standard	Wholeseed	14	1.7	1.5	13.7	29.4

Source : Ramchar et. al. 1975

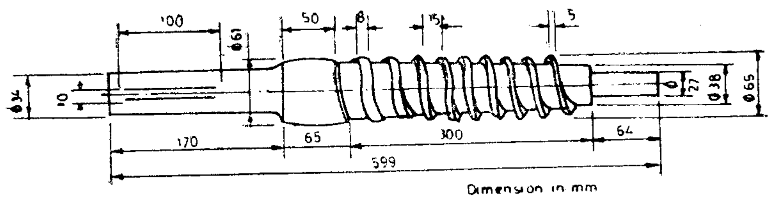
Table 8.3 : Filling of improved streins of Indian sunflower seed

S. No.	Experiment		Oil percent	Cake percent	Filter press and mud sediment percent
1.	**Whole seed**				
1.	1st pressed	13.7			
	2nd pressed	16.1	32.1	65.7	2.1
	3rd pressed	32.1			
2.	**Rolled seed**				
	1st pressed	17.6			
	2nd "	12.2	32.1	65.7	2.1
	3rd "	2.3			
3.	**Dehulled seed**				
	1st pressed	23.4			
	2nd "	9.4	34.0	44.6	4.3
	3rd "	1.2			
4.	**Deulled seed**				
	1st pressed	26.8			
	2nd "	6.4	34.8	42.6	5.0
	3rd "	1.6			

Ref : Ali. Y. et. al.

Studies have been conducted at CIAE, Bhopal for performance evaluation of Mini-40 screw expeller and Table oil expeller, manufactured by M/s SP Engg Corporation, Kanpur for extraction of oil from sunflower. Various pre-treatments given to seed of Modren variety, containing 40.5% oil, included instant addition of water, addition of calculated amount of water in the seed 24 h prior to expression and putting the seed in polyethylene bags so that seeds could attain uniform moisture content (defined as equivalent moisture content), size reduction/pulverization followed by instant water addition. Table 8.4 shows the effects of different seed pre-treatments on the capacity, extraction efficiency, oil output and oil left in cake after 2 passes.

The extraction efficiency of expellers, driven by 3 Hp electric motors increased from 48.9% to 82.7% in case of Mini-40 expeller and from 64.2% to 95% in case of Table oil expeller, shown in Fig. 8.10 for seed containing 4.1 to 8.7% moisture content raised by instant water addition. Further increaes in moisture content by instant water addition reduces the extraction efficiency in case of both expellers. Similarly, in case of seed which were treated by mixing water 24 h



Worm Shaft of Table Oil Expeller

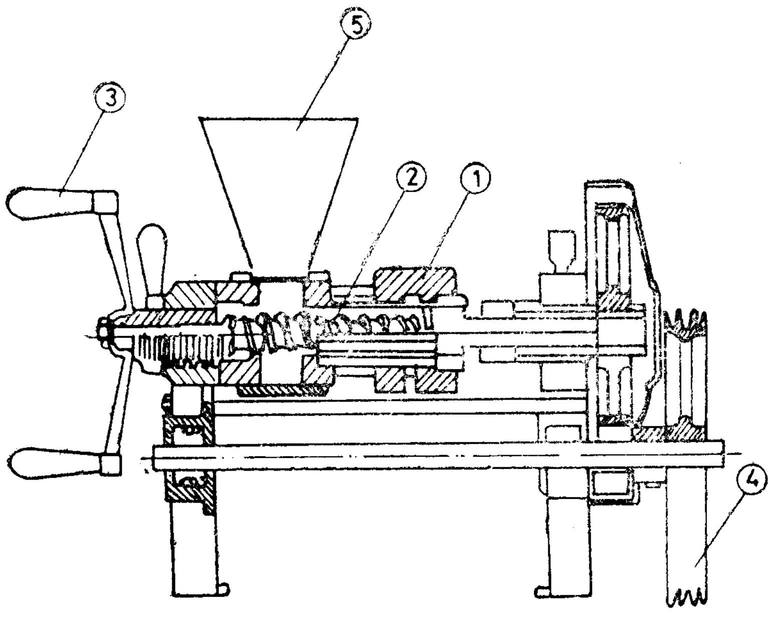


Fig 8.10 Cross Section Table Oil Expeller

1. Drum 2. Worm Shaft 3. Handle 4. Pulley 5. Hopper

prior to expression, the maximum extraction efficiency is obtained when seed moisture ranges between 8.5 to 8.67%. Further increase in seed moisture decreases the extraction efficiencv of both expellers as shown in Figs. 8.11, 8.12 and 8 13. Size reduction i. e. pulverization of seed and instant water addition helps in better oil recovery in case of table oil expeller. The higher extraction efficiency resulted in lesser oil left in cake which was lowest 9% in case of Mini-40 expeller at about 6 5% moisture content of seed and about 4% in case of table oil expeller at seed moisture content of 8.6%. The average capacity of both the expellers, based on 2 passes (crushing) is in the range of 7-10 Kg seed/h. The study showed that :

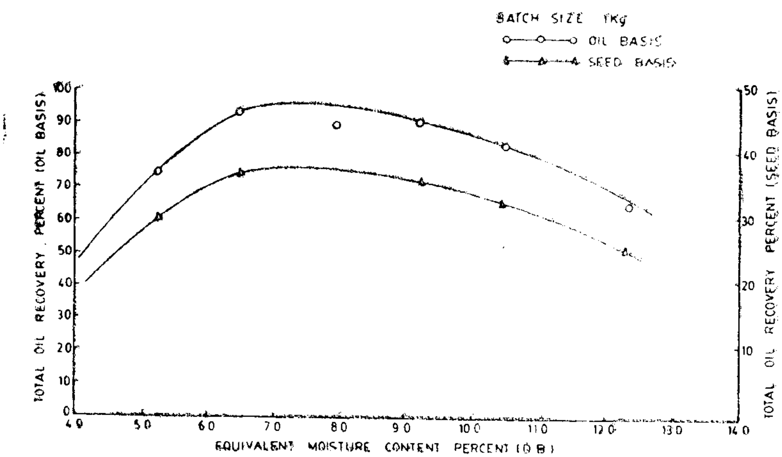


Fig. 8.11 Effect of Equivelent Moisture content on Recovery of Oil from Undecorticated Sunflower Seed Using Mini-40 Expeller

(a) The percent oil recovery from sunflower seed increases with increase in seed moisture content in the range of 4.2 to 8.7% (w. b.). The maximum oil recovery is obtained at seed moisture content of 8-9% (w. b.).

(b) Both, mini-40 and table oil expellers are suilable for oil extraction from sunflower. The Mini-40 expeller has a capacity of 7.2 kg seed input/h yielding 2 5 kg oil and its extraction efficiency varies between 48.9 to 85.2% whereas the table oil expeller has a capacity of 10 Kg seed input/h yielding 3.9 Kg oil/h and its extraction efficiency varies between 64.2 to 95% depending upon the seed pre-treatment in 2 crushings.

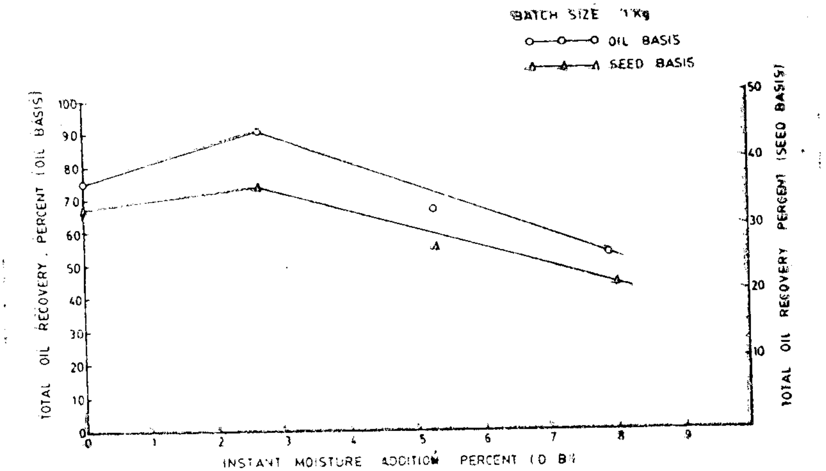


Fig. 8.12 Effect of Instant Moisture Addition on Total Oil Recovery from Undecorticated Sunflower Seed Using Mini-40 Expeller

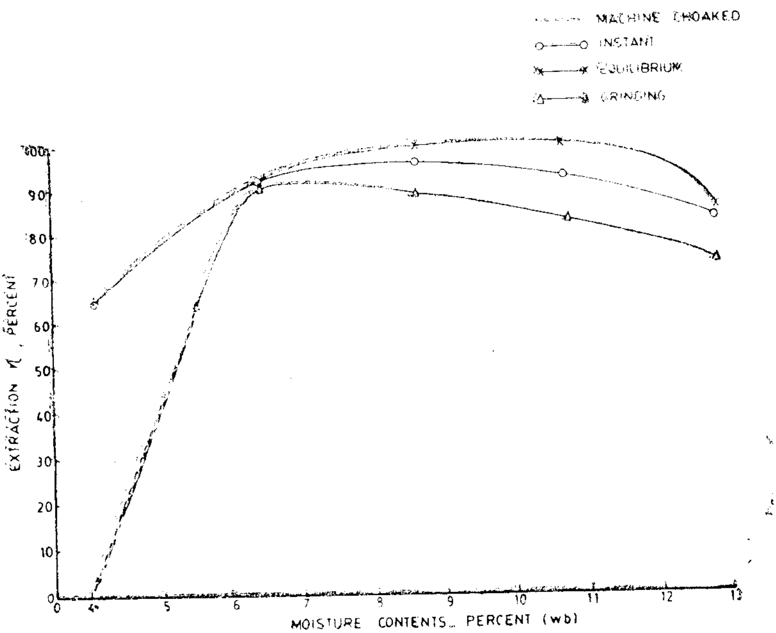


Fig. 8.13 Effect of Different Seed Pre-Treatments on Extraction Efficiency of Table Oil Expeller

Table 8 4 : Comparative performance of mini-40 and table oil expellers for sunflower seed (2 pass basis)

Expeller/Seed treament	M. C. of seed, %	Extraction efficiency, %	Capacity, kg/h	Oil Output, kg/h	Percent oil left in cake
Mini-40 Sxpeller					
a) No treatment	4.17	48.88	5.80	1.15	25.81
b) Instant water addition	5.60	68.02	12.00	3.31	17.87
	7.69	82.71	12.00	4.02	10.53
	10.32	77.53	15.32	4.81	13.27
	12.98	45.19	6.50	1.19	27.17
c) Mixing calculated amount of water 24 hours prior to expression	6.50	85.19	7.13	2.46	9.60
	7.89	80.98	11.80	3.87	11.46
	9.50	80.49	10.75	3.50	11.72
	10.52	81.48	11.61	3.83	11.19
	12.36	25.68	6.50	0.67	33.59
d) Pulverization and instant water addition	4.10	61.73	12.00	3.00	15.50
	6.40	77.78	12.00	3.78	9.00
Table Oil Expeller					
a) No treatment	4.10	64.19	10.90	2.25	19.59
b) Instant water addition	6.40	91.36	6.67	2.47	5.56
	8.67	95.86	10.00	3.84	3.25
	10.79	83.96	6.67	2.27	9.85
	12.82	81.72	2.40	0.59	20.67
c) Mixing calculated amount of water 24 hours prior to expression	6.40	91.35	6.67	2.47	5.56
	8.67	96.06	10.00	3.99	3.25
	10.79	83.95	8.67	2.91	9.85
	12.82	81.48	6.57	2.20	11.19
d) Pulverization and instant water addition	6.40	92.59	10.00	3.75	4.80
	8.70	81.48	10.00	3.30	11.19
	10.80	81.48	6.00	1.98	11.19
	12.82	71.60	6.00	1.74	16.19

In addition, the effect of decortication on oil recovery was also studied at CIAE, Bhopal. Oil recovery upto 33% was obtained by partial decortication of seed, mixing 60% whole and 40% decorticated seed as shown in Fig 8.14 (Srivastava et. al. 1990).

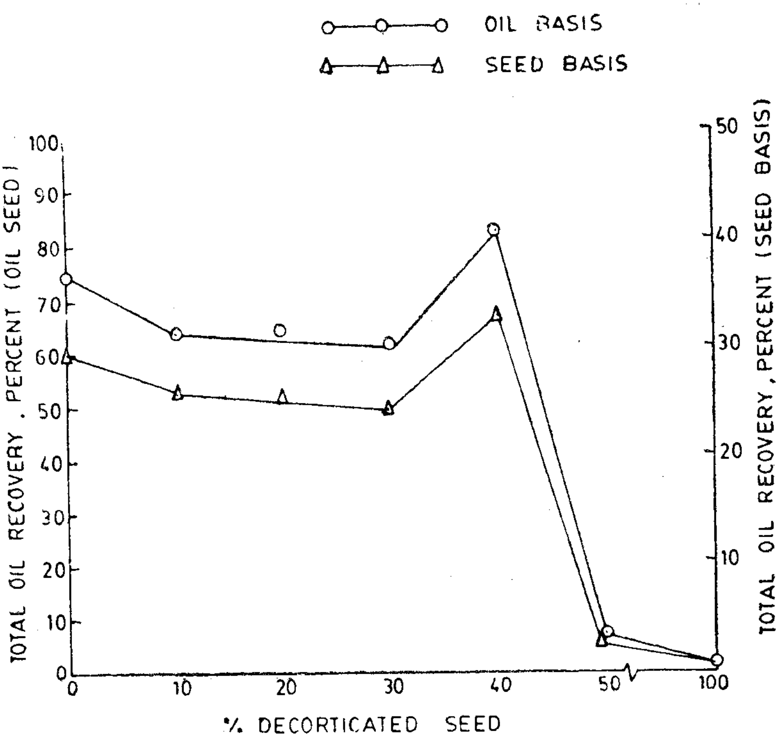


Fig. 8.14 Effect of Decortication of Sunflower Seed on Oil Recovery by Screw Press

Based on the best performance results of the two expellers studied at CIAE, Bhopal, the econmics of their uses have been worked out as shown in Table 8.5 The economic analysis shows that the use of such expellers is economically viable giving a net profit of Rs. 80-160/d, break even point of 69.4-48.9 q/y and return-on investment of 60-120% The two expellers could be used for other oilseeds also.

Table 8.5 : Economic analysis of the expellers

S. No.	Description	Mini-40 expeller	Table oil expeller
1.	Fixed capital, Rs.		
	a) Cost of expeller with accessories, Rs.	10,000.00	10,000.00
	b) Installation charge, Rs.	2,000.00	2.000.00
	Sub Total : Rs.	12.000.00	12,000.00
2.	Fixed charges, Rs./h		
	a) Interest at the rate of 15%,	2.50	2.50
	b) Depreciation,	1.50	1.50
	c) Repairs and maintenance at the rate of 2% of fixed capital,	0.33	0.33
	d) Housing charges, at the rate of Rs. 50/month	0.21	0.21
	Sub Total : Rs.	4.54	4.54
3.	Operating expenditure, Rs/h		
	a) Labour charges for 2 persons, at the rate of Rs. 25/day	6.25	6.25
	b) Power charges, at the rate of Rs. 0.50/unit	1.00	1.00
	c) Cost of raw material, Rs. at the rate of Rs. 6/kg	43.20	60.00
	Sub Total : Rs.	50.45	67.25
4.	Cost of production Rs.		
	a) Fixed charges	4.54	4.54
	b) Operating charges	50.45	67.25
	Sub Total : Rs.	54.99	71 79
6.	Oil output, Kg/h	2.50	3.99
5.	Oil cake output, kg/h	7.50	6.00
7.	Cost of oil produced, Rs/h at the rate of Rs. 20/kg	50.00	79.80
8.	Cost of cake produced at the rate of Rs. 2/kg	15.00	12.00
9.	Total income, Rs/h	65.00	91.80
10.	Profit, Rs/h (9–4)	10.00	20.01
11.	Profit, Rs./d	80.00	160 00
12.	Break even point, q/y	59.38	48 88
13.	Pay back period, y	1.44	0.78
14.	Return-on-investment, %	60.00	120.00
15.	Employment generated per unit for sunflower oil expelling	180.00	180.00

Based on similar studies conducted at PAU, Ludhiana, the economics of sunflower processing using a small expeller (rated capacity 40 Kg/h) has been worked out by Shashi Paul et.al. (1989) with following assumption.

(a) Expeller runs for 8 h/d and for 30 d/y for sunflower processing. Thus in all 96 q seeds could be processed/season or 288 q/y.

(b) Drying if required is done by sundrying method. Table 8.6 presents the economics.

Table 8.6 : Economic analysis for processing of sunflower seed

S. No.	Description	Amount (Rs)	Remerks
A.	Fixed capital :		
1.	Oil expeller (69.5 × 12.5 cm) capacity 40 kg/h	15,000.00	
2	Filter press (30.5 × 30.5 cm) with 12 fiiter plates, filter pump and filter cloth etc.	6,000.00	
3.	Motor/diesel engine	8,000.00	
4.	Installation, small shed etc.	2,000.00	
5.	Electric fittings and misc.	4,000.00	
		35,000.00	
B.	Fixed charges, Rs/h		
1.	Interest at the rate of 15% on Rs. 35000	7.30	
2.	Depreciation on plant and machinery.	4.85	Life taken : 10 y. straight-line Depreciation
3.	Repairs and maintenance at the rate of Rs. 2% of the fixed capital	0.97	
		13.12	

C. Operating expenditure, Rs/h		
1. Labour, 2 persons at the rate of Rs. 24 per day	6.00	
2. Diesel oil/Lubricants	10.00	
3. Transportation of oil and oilcake	5.00	
4. Cost of raw material for 40 kg at the rate of Rs. 3.05/Kg	122.00	
5. Cost of tin	5.00	
	148.00	
D. Cost of production, Rs/h		
1. Fixed charges	13.12	
2. Operating expenditure	148.00	
	161.12	(B+C)
E. Sales per hour :		
Sunflower seed : 40.00 kg		
Oil recovery : 13.20 kg		
Oilcake : 26.80 kg		
1. Income from oil at the rate of Rs. 20/- per kg.	264.00	
2. Income from oilcake at the rate of Rs. 2/- per kg	53.60	
	317.60	
F. Profits :		
1. Cost of production, Rs/h	161.12	
2. Income per hour from sales, Rs	317.60	
3. Profit per hour, Rs	156.48	
4. Profit per kg of raw material, Rs	3.91	
5. Profit per acre, Rs	2,738.40,	Yield : 7 q/acre
6. Cost of sunflower production per acre.	875.00	
7. Net returns after processing of seed	1,863.40	(5—6)

TDRI, U. K. has developed one hand operated hydraulic press, shown in Fig. 8.15 which could be used for sunflower, niger and groundnut seed processing. The unit consists of a cage type chamber which has small holes of 3mm diameter at the bottom for extraction of oil. A pressure of 8t for about 2 minutes is required for recovery of 25% oil. Decortication of seed is however, essential for effective oil recovery.

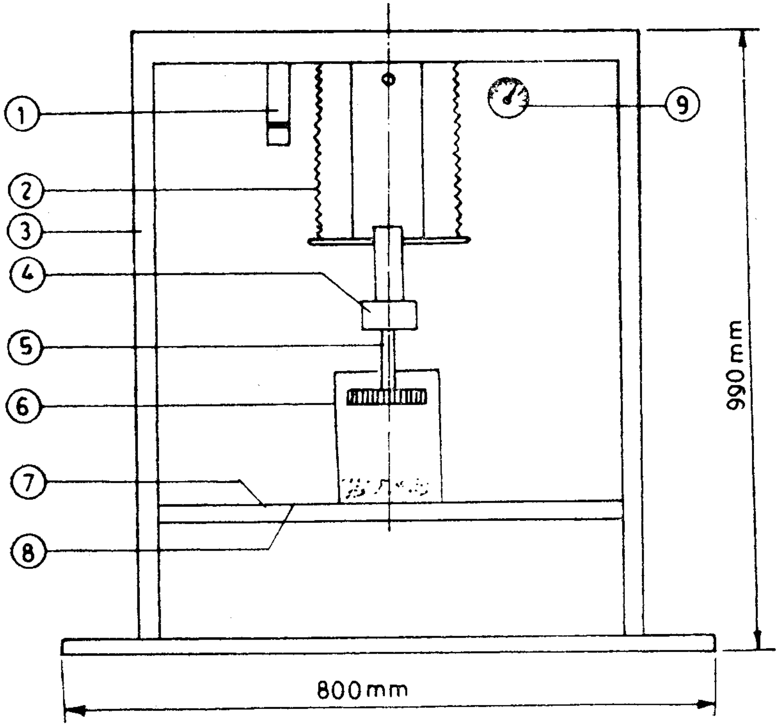


Fig. 8.15 Hydraulic Oil Press

1. Hand Operated Pump 2. Reversible Spring 3. Banch Press 4. Ram 5. Piston 6. Cage 7. Adjustable Table 8. Tray for Oil 9. Pressure Gauge

8.7 Utilization of Cake

The deoiled meal/cake of sunflower is used as animal feed. Laboratory defatted sunflower flours have been reported as possessing high protein contents, bland flavours, white colour at acid PH levels and containing no anti-nutritive factors. Functional test data show that sunflower flours and concentrates have high salt solubility, oil absorption and oil emulsification. High weight gains in rat fat feeding trials were obtained for sunflower blends with legume and animal proteins, suggesting their applications in milk and meat extenders and in soybean based infant formulas. Heat treatmants, mechanical agitation and emulsification are reported to be effective in stabilizing 80% of sunflower proteins. Sunflower flour slurries show excellent whippability and foam stability, comparable to that of soybean protein isolate but lack the ability to form a firm gel. Spun sunflower protein casein (1 : 1) blends are superior to other vegetable proteins in shear strength, swellability and firmness. Sunflower proteins in particular have unique organoleptic and functional properties which could expand the range of food uses for concentrated seed protein, Table 8.7 gives the composition of sunflower products while Table 8.8 gives the protein nutritive value of sunflower blends with cereals, legume, animal products and lysine as reported by Sosulski and Fleming (1979). Table 8.9 and 8.10 show the colour and flavour of 3% protein extract from sunflower concentrate and soybean flour and their blends with milk (1 : 1) and essential amine acid contents of sunflower and its blends with milk (1 : 1). Bakery products can also be prepared from sunflower and wheat flour

Table 8.7 : Composition of sunflower products

Protein products	Protein %	Fat %	Fibre %	Ash %
Kernel	26.1	56.3	2.5	3.6
Flour	53.0	1.8	3.6	8.2
Concentrate	68.6	1.0	5.1	6.9
Isolate	87.7	0.1	0.5	3.2

Source : Food Uses of Sunflower proteins. J.A.O.C.S. SG : 432–442

Table 8.8 : Protein nutritive value of sunflower-bleands with cereal, lequme, animal proteins and lysine (tested with rats)

Protein Source	Feed Cousum-ption, g/rat	Weight gain, g/rat	Protein-Efficiency, Ratio
Casein	264	72.8	2.50
Sunflower Concentrate	229	51.9	2.00
+ Wheat flour	241	36.4	1.34
+ Peas	342	101.7	2.65
+ Ground beef	292	92.8	2.82
+ Lysine	339	116.7	3.06

* Protein efficiency. ratio adjusted to Casein = 2.50

Source : Sosulski, F. 1979 Food uses of sunflower proteins JAOCS 56 : 438-442.

Table 8.9 : Colour and flavour of 3% protein extract from sunflower conceotrate and its blend with milk (1:1)

Protein	Temperature, °C	Characteristics of 3% extract		Characteristics of extract milk blend	
		Colour	Cereal like	Colour	Flavour
Sunflower	25	Grey	Cereal like	Greyish white	Slight cereal
Sunflower	70	Grey	Elight-cereal	Milk-white	Slight cereal

Source : Soslski, F. 1979. Food Uses of Sunflower Proteins J.A.O.C.S. 56 : 438-442

8 8 Storage and Packaging of Oil

Sunflower oil is used for boiling, stewing, frying and roasting of food materials. However it is reported to be susceptible to light and heat and shouid therefore be stored in a dark and cool place. The oil could be stored even for one year under cold conditions in glass or

Table 8.10 : Essential amino acid content of sunflower proteins and its blend with milk

Amine acids	Cow's milk	Sunflower concentrate	Sunflower milk (1 : 1)
	Amino acid	(g amine acid/100 g protein)	
Isoleucine	4.7	3.6	4.2
Loucine	9.5	5.5	7.5
Lysine	7.8	2.7	5.8
Metkionine crystine	3.3	3.6	3.5
Phenylalanine tyrosine	10.2	6.2	8.2
Threonine	4.4	3.0	3.7
Tryptophan	1.4	1.2	1.3
Vatine	6.4	4.4	5.4

Source : Sosulski, F. 1979 Food Uses of Sunflower Proteins J.A.O.C.S. 56 : 438–442

plastic bottles. By its hydrogenation, vegetable fat, ghee and margarine could also be produced.

8.9 By-Product Utilization

Hulls obtained during decortication of sunflower have high fibre content and can be used as a roughage in certain animal feeds. Altrenately, they can be used to produce heat by burning, as they yield the same amount ol heat as lignite coal.

8.10 Storage of Seed

Studies conducted at CIAE, Bhopal for storage of sunflower seeds in various structures namely mud bin, coaltar drum bin, black and white polyethylene bags have indicated the suitability of last 3 structures. Table 8.11 reports the nominal variations in fat content, protein content and FFA content of seeds in these structures during 6 month storage. The mud bin was not found suitable for storage of sunflower seeds due to attack of rodents which completely spoiled the bin.

Table 8 11 : Variation in bio-chamical parameters during 6 months storage of sunflowers eeds.

Parameter	Storage structures					
	Coaltar drum bin		P. E. bag		Plastic bag	
	Initial	Final	Initial	Final	Initial	Final
Fat, %	40.39	39.68	40.39	39.64	40.39	39.64
Protein, N × 6.25%	3.32	3.24	3.32	3.30	3.32	3.28
	20.80	20.25	20.80	20.59	20.80	20.50
FFA, % Oleic	0.95	1.42	0.95	0.98	0.95	0.97

Similar studies conducted at UAS, Bangalore with mud pot, metal bins, polythene bags, cloth bags and gunny bags storing sunflower seeds for a month have shown that the seeds are infested with *Ephestia Cantella* (walker). However, this study shows that mud pot is the safest structure followed by PE bag, metal bin, cloth bag and gunny bag in order of increased infestation as shown in Fig. 8.16.

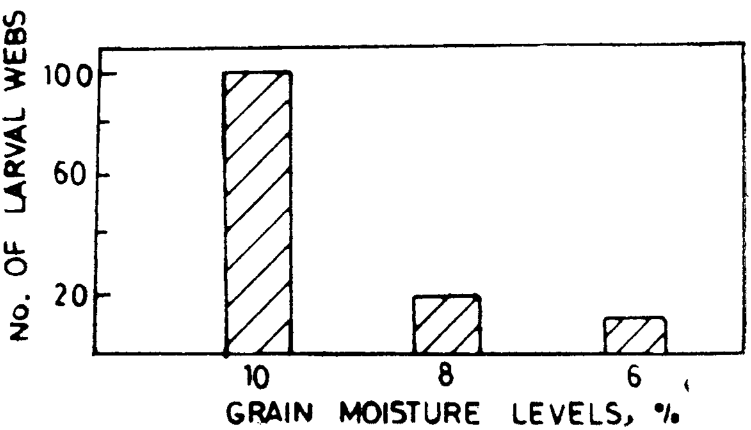


Fig 8.16 Number of Larval Webs of Ephestia Cantella in Different Storage Structures

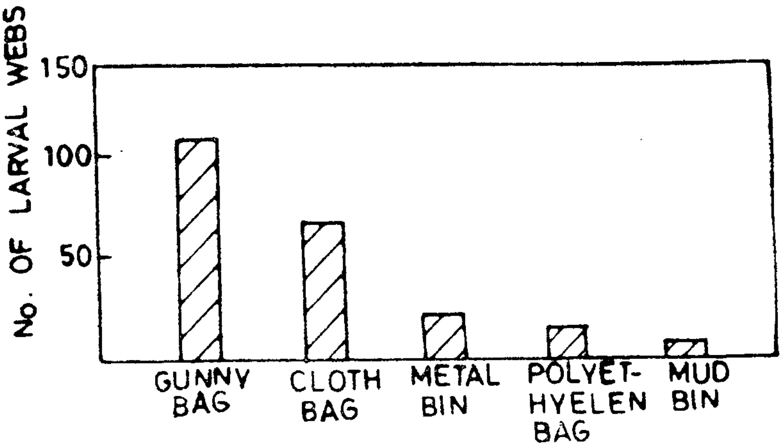


Fig. 8.17 Extent of Infestation by Ephestia Cantella et Different Moisture Levels in Sunflower Seed

Infestation is highest in seeds stored at higher moisture levels and least in seeds at low moisture levels as shown in Fig. 8.17.

9. CASTOR

Castor *(Ricinus communis)*, one of the important commercial crops is mainly grown in Gujarat, Andhra-Pradesh, Karnataka, Orissa and Tamil Nadu. In Tamil Nadu, it is grown mainly as intercrop with groundnut, turmeric, sugarcane, etc. India produces about 0.35 million tonnes of castor annually. It's main product is oil, used in paints, lubricants, soaps, perfumed hair oils, medicines and as raw meterial in plastic industry It could be used for the production of nylon due to its 92-94% ricinoleic acid content (Duffus and Slaughter, 1980). The general productivity level of castor in India is hardly 30-40% realizable potential because of inefficient varietal choke and crop management. The results of maximization trials have indicated that the yields of castor and the returns from the crop could be stepped up by 150% under rainfed conditions. Unfortunately not much attention has been given on production and post-production aspects of this crop. This chapter, however, describes the conventional methods and improved technology developed at the various organizations for castor's processing.

9.1 Seed Characteristics

The castor capsule generally consists of three cells and each cell contains one kernel as shown in Fig. 9.1. The average major and minor dimensions of the capsule [variety GAU (CH-1)] are 16.5 and 14.5 mm respectively. During shelling operation, the castor capsule easily breaks into three cells but removal of kernels from the cells poses a problem. The bondage between shell and kernel is such that an accurate force should be applied to crack the shell but not to damage the kernel. This can be achieved by impact and rubbing. The average length, width and thickness of individual cell are 15.0, 9.0 and 6 75 mm respectively for GAU (CH-1) variety while the dimensions of kernels are 11.6, 8.00 and 5.9 mm respectively The bulk densities of kernel and chaff are 0 44 and 0 73 respectively which facilitates in easy cleaning of shelled products.

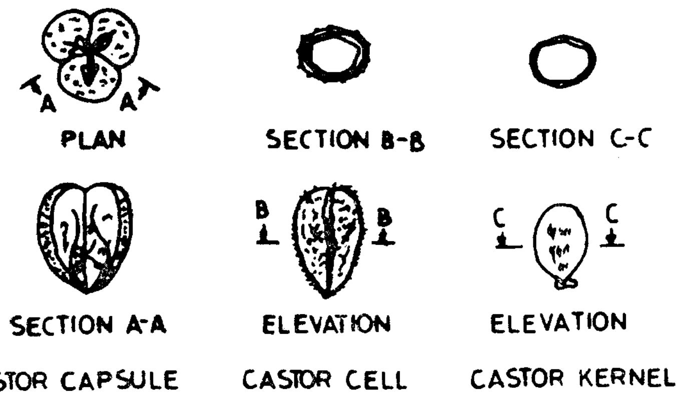


Fig. 9.1 Morphological Details of Caspsule

Shedding of the outer shell of the fruit which may occur naturally at maturity is 'decortication' and this frees three seeds. Removal of the shell from the seeds is dehulling and this releases the bean or kernel. The skin of the beans is of creamy white oil-rich colour. Including the skin, oil content of different varieties of bean ranges from 35-60%. It also contains moisture (4-8%), soluble carbohydrate, fibre, protein and mineral which, yields 2-3% ash when the bean is ashed, The seeds contain ricinnine, a very mildly toxic alkaloid, ricin, an extremely poisonous protein twice as potent as prussic acid yet destroyed by moist cooking, and a powerful heat stable allergen, acutely irritating to humans, if not to animals. They also contain an active lipolytic enzyme which promptly goes into action if seeds are damaged or wet. Fortunately the poisons and the allergen are not extracted along with the oil, but remains with seeds press cakes and meal which are poisonous. For this reason, castor beans are processed on separate equipment specially meant for this purpose.

9.2 Traditional Processing

Traditionally the improved varieties of castor are harvested soon after the spikes are fully dry while the local types have shattering capusules and harvesting of spikes is done before they dry up and while the capsules are still green. The harvested spikes are stacked in heaps till the capsules blacken, spread out and dried in the sun

Sometimes, water mixed with cowdung is sprinkled on the heap or spikes and are stored in a pit and covered with cowdung and earth for 3–4 days. Later the seeds are beaten out of the capsules by stick or threshed by bullock treading. It is reported that both, the content and quality of oil are impaired when seeds are harvested and threshed in this manner because of the fermentation that takes place when the capsules are heaped together and also because of the immaturity of a larger part of seeds, at harvesting time. Hardly any sorting or grading of the seeds is carried out as the bulk of the crop is marketed by producers without cleaning. Castorseed can be stored for 2-3 years in gunny bags or in closed/open containers without having any measurement of the content or quality of oil present in the same. However, decorticated seeds store well for only 30–45 days after which oil quality deteriorates rapidly. The seeds meant for sowing purposes need to be stored in a cool palce. Their viability is reduced at room temperature by 75% during 3 months and is completely lost in about 25 days when stored at 50°C.

In India, the bulk of seed produced is utilized for expression of oil. Castor oil is the most important product of seed which is used in medicine as a Catharic but its major use is in preparation of a variety of industrial products. Seed cake contains toxic constituents and hence is not used as animal feed. Castor oil obtained by crushing whole or decorticated seeds in a power driven hydraulic press (capacity 10–12 t/d), expeller (3-4 t/d capacity), rotary mills, bullock driven ghanies and even in manually operated presses (0.5 t/d capacity). However, ghani is used to limited extent due to low capacity (35-60 kg/d) and lower oil recovery. The seed contains about 49% oil and the oil yield varies between 30-42%, as given below, depending on the method and equipment used

Expellers/hyraulic press	:	30-42%
Rotary mill / screw press	:	39%
Village ghani	:	35%

Hydraulic decreases 12% oil in cake. In solvent extraction cake has oil content less than 1% and the quality is also good (Janson 1947). In India, bulk crushing of castor seed is done without decortication of seed.

The seeds after cleaning and sometimes decortication are crushed either in hydraulic or more commonly screw presses. Usually good quality seeds, processed under mild conditions of temperature and pressure, yield medicinal grade castor oil. At higher temperatures and pressures, the yield of oil improves while the quality decreases. The oil is steamed for degumming, dried after separation of gums and filteied. When necessary, treatment with sodium carbonate to lower free fatty acid content, bleaching with earth end carbon and deodorisation to remove colour and odour are carried out.

9.3 Storage of Seed

It is recommonded that castor seeds be dried to 7-8% misture content (wb) before storing. At domestic or farm level, storage of large quantities of castor seed is not recommended as it accupies a considerable space. Castor seed is also not recommended to be stored in open as both heat and sunlight damage the germination and reduce the oil content. Artificial low temperature storage also affects the viability as has been reported by Blagdyr and Sevastyanora (1975) that castor seed stored at 5 to 7°C temperature for 6 months reduced the germination from 93 to 3%. During bagging the seeds, handling should be minimized. On large scale handling, wooden scoops, shovels and rubber conveyor belts are recommended. Seeds should be stored at dry place and cooler part of the house.

9.4 Shelling

Shelling is the major operation in castor bean processing. Traditionaliv, castor bean is shelled after drying on floor under sunlight. Manually beating or rubbing the dried fruits with wooden planks consumes human energy and time. Treading under the bullock feet or tractor is also practised. These conventional methods are not only uneconomical but also deteriorate the quality of seeds.

Studies have been conducted at TNAU, Coimbatore for evaluating the performance of the groundnut decorticators for shelling castor (Duraiswamy and Manian, 1989). The groundnut decorticator used in this study was hand operated (Fig 4.13) and also a power operated decorticator (Fig. 4.14), described in chapter-4 was evaluated. For shelling castor with these two decorticators, the sieves with 6×20 mm holes with different orientations, as shown in Fig. 9.2 were used. Table 9.1 shows the results obtained with three different sieves for shelling the castor.

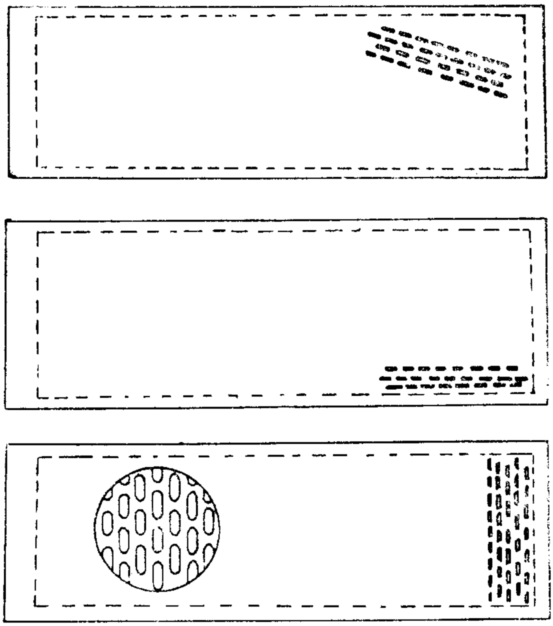


Fig. 9.2 Sieves with Slots at Three Different Orientations

Table 9.1 : Effect of slot perforation orientation on decorticators performance

Sl. No.	Position of slots to the direction of oscillation	Wt. of pods tested, kg	Size of kernels, mm 1, b, h	Shelling efficiency, %	Breakage of kernels, %	Unshelled seeds %
1.	Perpendicular	5	13.5, 8.5, 5.6	95.50	0.80	4.50
2.	Parallel	5	-do-	95.20	2.20	4.80
3.	Inclined	5	-do-	91.40	1.00	8.60

Source ; Durasiamy and Manian, 1989

Table 9.1 shows that shelling efficiency was more or less same in case of sieves with slots parpendicular and parallel to the direction of oscillation. But when the slots were perpendicular to the direction of oscillation the breakage of kernels was minimum. When the slots were inclined, the shelling efficiency was low.

Keeping in view the above study, sieve with slots perpendicular to the direction of oscillation was used in both, hand operated and power operated groundnut decorticators. Table 9.2 shows the performance of these two equipment for shelling of castor.

Table 9.2 : Peromance of decorticator for castor seed

Sl. No.	Particulars	Goundnut decorttcator		Conventional method of rubbing
		Power operated	Hand operated	
1.	Power required	1.0 hp	2 women	—
2.	Labour required	1 man	1 women	1 women
3.	Moisture content, %			
	Pods	—	4.12	—
	Husk	—	7.53	—
	Kernels	—	2.64	—
4.	Kernel/husk ratio	—	75.25	—
5.	Shelling capacity, kg (pods)/h	230.0	76.00	11.7
6.	Total cost of operation Rs./q pods [including cleaing (1989 basis)]	9.50	19.00	27.00
7.	Shelling efficiency, %	97.65	95.50	97.00
8.	Cleaning efficiency, %	99.16	—	—
9.	Breakage of kernels, %	2.27	1.26	0.48

Source : Duraisamy and Manian. 1989

Thus castor may be decorticated with slight modification in existing TNAU groundnut decorticators. When it is shelled with power operated decorticator with sieves containing 20×6 mm slots perpendicular to the direction of oscillation, the shelling capacity is 230 kg pod/h with a shelling efficiency of 97.65% and breakage of 2.27% kernels. The equipment has 99,17% cleaning efficiency.

In case of hand operated decorticator, fitted with sieves of 20×6 mm perpendicular slots, a shelling capacity of 76 kg pods/h, shelling efficiency of 95.50% and breakage of 1 26% kernels is obtained while the shelling rate by conventional method of rubbing is only 11.7 kg pod/h with 97% shelling efficiency.

TNAU, Coimbatore has further designed and developed hand and power operated castor shellers (Fig. 9.3). The sheller consists of a

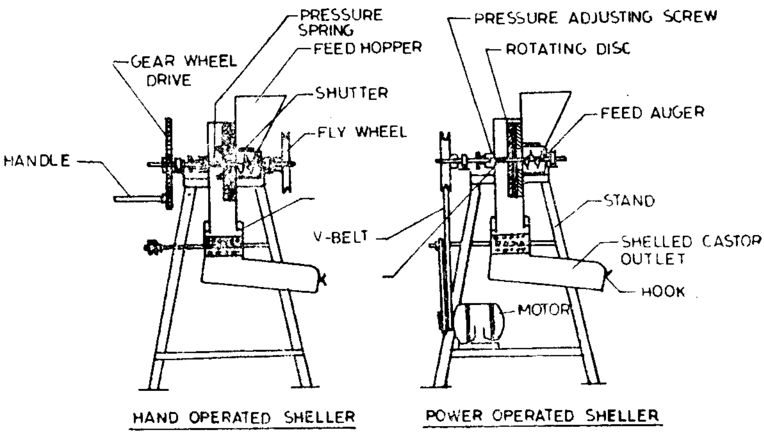


Fig. 9.3 Tanu Castor Sheller

trapezoidal shaped feeding hopper tapering towards the bottom with a shutter to regulate the feed rate. Below the shutter a screw auger is provided which passes the castor pods to the shelling portion. The shelling portion consists of two wooden discs fastened with 6 mm thick rubber sheet over the rubbing faces. One disc is mounted on the shaft and the other is rigidly fixed to the frame. The disc mounted on the shaft is held against the stationary disc by means of a compression spring, the tension of which can be adjusted by rotating a screw provided for it The clearence between the discs can be adjusted to accomodate different sizes of castor by sliding the rotating disc on the shaft. To clean the shelled kernels, a blower is fitted. The unit may be operated either manually or by a 0.5 hp electric motor. During operation with electric power, the drive for the auger shaft is given by a V-belt through the grooves over the flywheel itself. For manual operation, the flywheel is mounted on the other end of the shaft and the gears and handle are fitted in that place. The electric power is disconnected during manual operation.

The castor pods are fed into the hopper. From the hopper they are taken in between the shelling discs by means of the auger The quantity of castor pods fed into the shelling portion is controlled by means of a shutter provided at the bottom of the hopper. Due to the pressure exerted and rubbing action provided on the castor pods by the rotating disc, the castor seeds are separated from the pods and collected at the bottom alongwith husk, which is separated either by wind (in hand operated equipment) or by blower (in power operated equipment). The specifications of these two units are given in Table 9.3 while Table 9.4 gives the performance results.

APAU, Hyderabad has developed two equipments for shelling and shelling-cum-winnowing of castor pods. Figures 9.4 and 9.5 shows these two equipments while Table 9.5 presents the specifications and test results of these equipments.

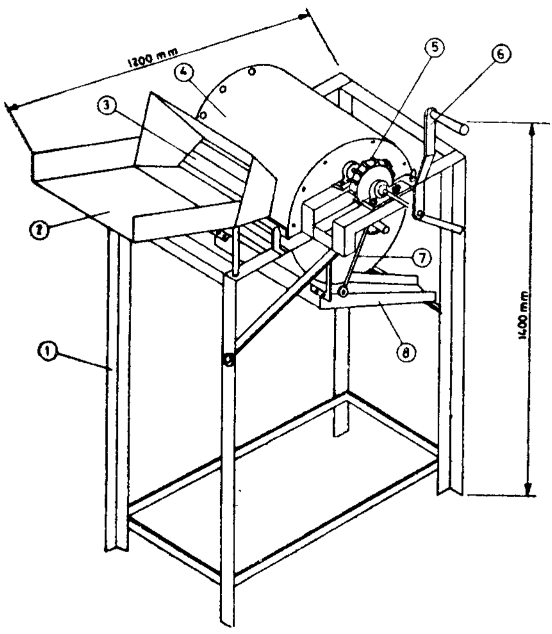


Fig. 9.4 Castor Shellar

1. Frame 2. Feeding Chute 3. Cylinder 4. Cylinder Cover 5. Drive Mechanism 6. Crank 7. Clearance Adjustment 8. Discharge Chute

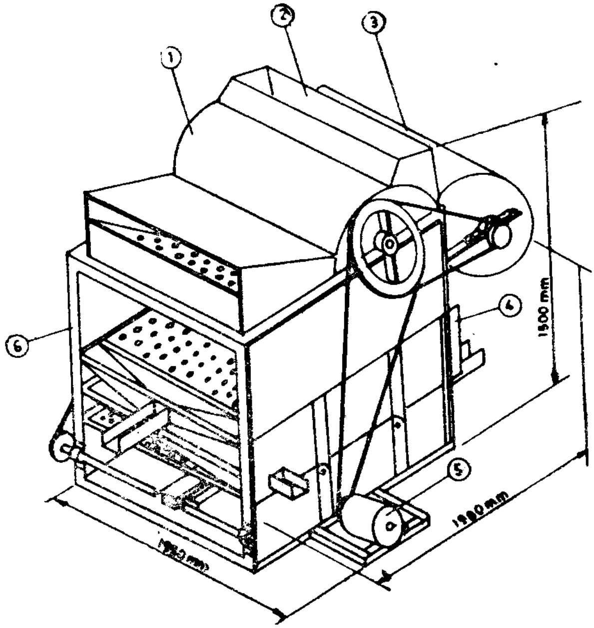


Fig 9 5 Castor Sheller-Cum-Winnower

1. Cylinder Cover 2. Feeding Hopper 3. Fan Assembly
4 Sieve Assembly 5. Motor 6 Main Frame

Table 9.3 Specification of castor shellers developed at TNAU, Coimbatore

Particulars	Power operated sheller	hand operated sheller
Overall dimensions, mm	150 × 800 × 1320	105 × 600 × 1320
Weight of equipment, kg	72.5	72.5
Power transmission system	V-belt	Gears
Shelling unit		
(i) type	Circular disc (one stationary)	
(ii) material	Wood with rubber bearing	
(iii) dimensions of main parts, mm	disc dia : 300 thickness : 35	

Clearence adjustment	Automatic spring tension agd manual adjustment	
Method of feeding	Forced feeding	
Power requirement	0.5 hp	Manual
Labour requirement	One man	Two men
Cost, Rs.	2000 (1990)	1,400 (1990)

Source : Duraisamy and Manian (1990)

Table 9.4 Performance of TNAU castor shellers

Particulars	Power operated sheller	Hand operated sheller
Cylindrical drum, disc speed, rpm	210	200
Blower speed, rpm	2050	—
Output, % (through kernel outlet)		
pure kernels	64.64	66.56
unshelled pods	0.40	0.00
unshelled capsules	2.00	1.24
broken kernels	0.48	0.56
husk	2.52	29.80
immature kernels	0.28	1.56
Output, % (through blower outlet)		
pure kernels	2.64	—
unshelled pods	0.00	—
unshelled capsules	0.28	—
unshelled kernels	0.00	—
husk	25.24	—
immature kernels	1.40	—
shelling capacity, kg/h (pods)	163.00	52.63
cost of operation, Rs/q (pods) (including cleaning)	9.02	22.53
shelling efficiency, %	97.29	98.72
cleaning efficiency, %	90.99	—
breakage of kernels, %	0.72	0.88

Source : Duraisamy and Manian (1990)

Table 9.5 Comparative study of shellers for castor pods

Specifications/Test Results	Equipment Castor sheller	Costor sheller cum winnower
Type	Wooden ribbed drum	Cylinder and concave
Capacity. Kg/h	100 (seed)	250 (pods)
Power requirement, HP	Manual	2
Labour requirement	2	2
Cost of equipment, Rs.	1,200	8,000
Cost of operation, Rs/t	67.0	54.50

A castor decorticator, as shown in Fig 9 6, has also been developed at the Department of Rural Engineering, GAU, Dantiwada Campus (Varshney and Patel, 1985). The decorticator is operated by a 3hp electric motor. The test results of this equipment are given below:

Capacity, % q/h	: 2.5
Shelling efficiency, %	: 97.13
Cleaning efficiency, %	98.41
Visible damage, %	: 0.28
Grain loss, %	: 0.07
Germination, %	: 83.00
Energy consumption	
Electrical energy, Kwh/t of kernel	: 8.9
Human energy, man-h/t of kernel	: 15
Cost of equipment, Rs. (1991)	: 6,000/-

9.5 Value Addition

Castor oil is unique in having about 90% ricinoleic acid, a C-18 fatty acid with a hydroxyl group on the twelth carbon atom and a cis-double bond between carbon atoms 9 and 10. Because of this, castor oil yields a variety of industrial products, the potential of which, both for export as well a for internal usage is vast. RRL Hyderabad has developed a variety of value added products viz. hydrogenated castor

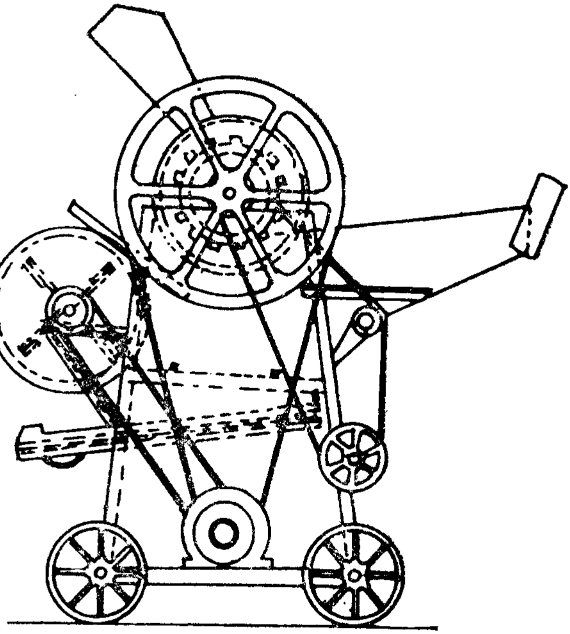


Fig. 9.6 G. A. U. Gastor Bean Decorticator

oil, hard fat. tristearin/stearic acid and triolein/oleic acid, dehydrated castor oil, dimer acids, heptaldehyde and undecenoic acid, sebacic acid and 2-octanol etc. (Lakshminarayana and Rao 1988) Figs. 9.7 to 9.15 show the process outlines for production of hydrogenated castor oil (HCO), hard fat for soap, searic acid and oleic acid, dehydrated castor oil (DCO) fatty acids, polyamides, sebacic acid and 2-octanol, fatty acids anc glycerol and sodium stearoly elaetylate, respectively. Hydrogenation of castor oil gives high melting wax-like product HCO, also called castor wax or opal wax which finds extensive use in the manufacture of 12-hydroxystearic acid, lithium based multipurpose grease, insulating materials, heat sealing adhesieves, mould releasing agents, coating composition for paper, textiles, leather and as antisagging and antisetting agents in paints HCO fatty acids find application in the manufacture of Li, Ca, Na and K based multipurpose greases, esters in cosmetics pharmaceuticals, wax substitutes, plasticizers, emulsifiers etc. Dehydrated castor oil (DCO) is a useful surface coating material noted for non-yellowing and colour retention properties.

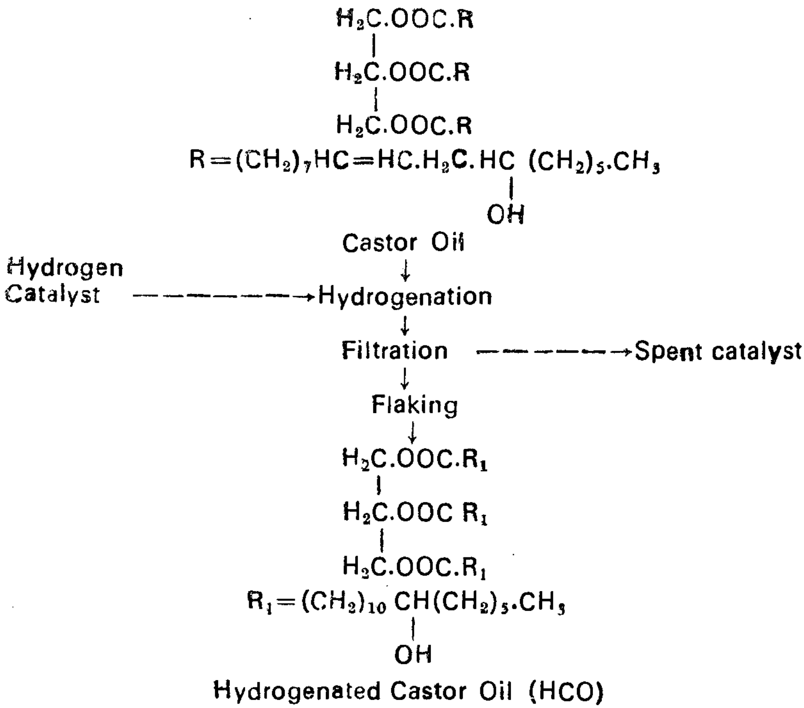


Fig 9.7 Process for Hydrogenated Castor Oil

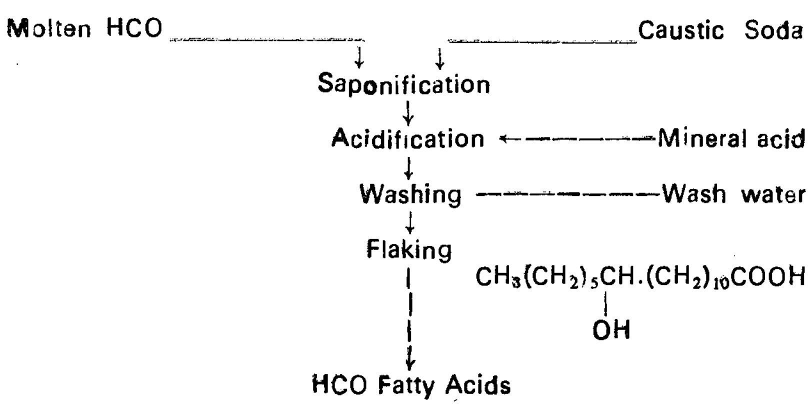


Fig. 9.8 Process Outline for HCO Fatty Acids

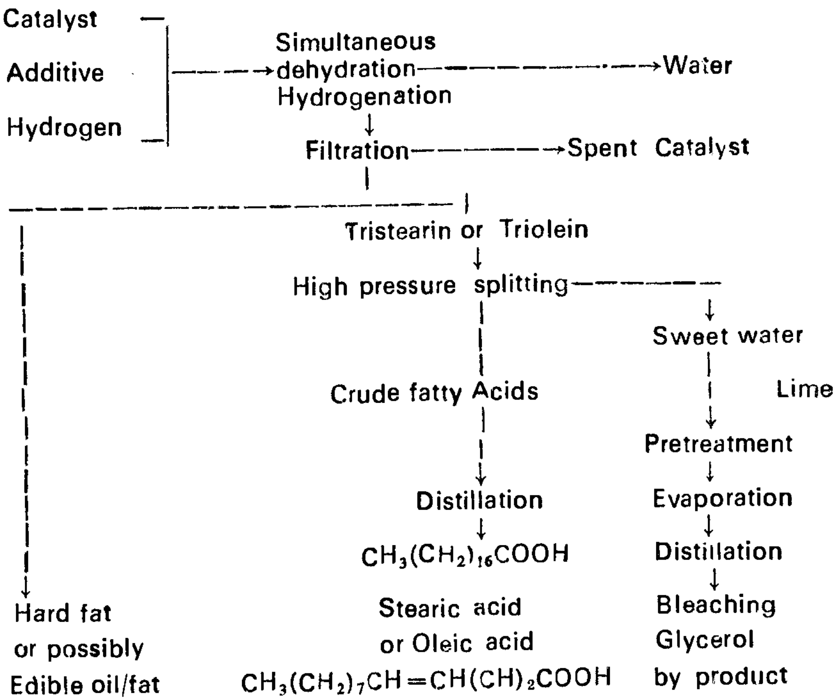


Fig. 9.9 Process Outlines for Soap, Stearic Acid and Oleic Acid

Sebacic acid finds applications in the manufacture of Nylon 6-10, plasticizers, jet lubricants etc. Similarly 2-Octanol is mainly used for preparation of plasticizers, antifoaming agents and as a solvent. These two products also have potential for export besides their use within country.

9.6 By-product Utlization

By products of castor crop like stalk, shell and leaves are not fully utilized. Table 9.6 presents the proximate analysis of castor stalks and shells, as reported by Bhoi and Varshney (1988). The calorific value of castor stalk is 4,747 K cal/kg which is comparable with 4,700 K cal/kg of firewood. Thus it could be very well used as source of low cost renewable energy. Moreover, the stalks could be used in

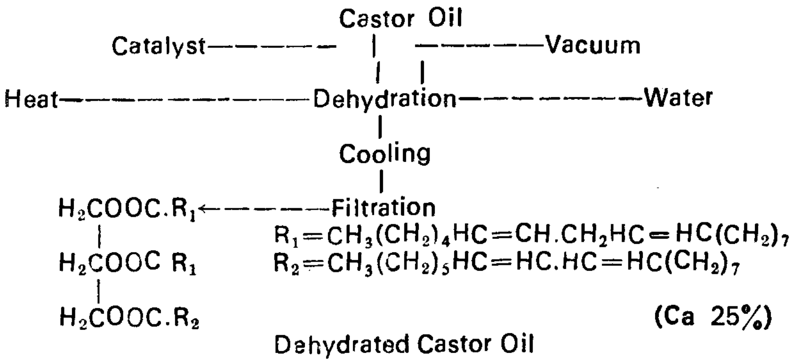


Fig. 9.10 Process Outline for Dehydrated Castor Oil

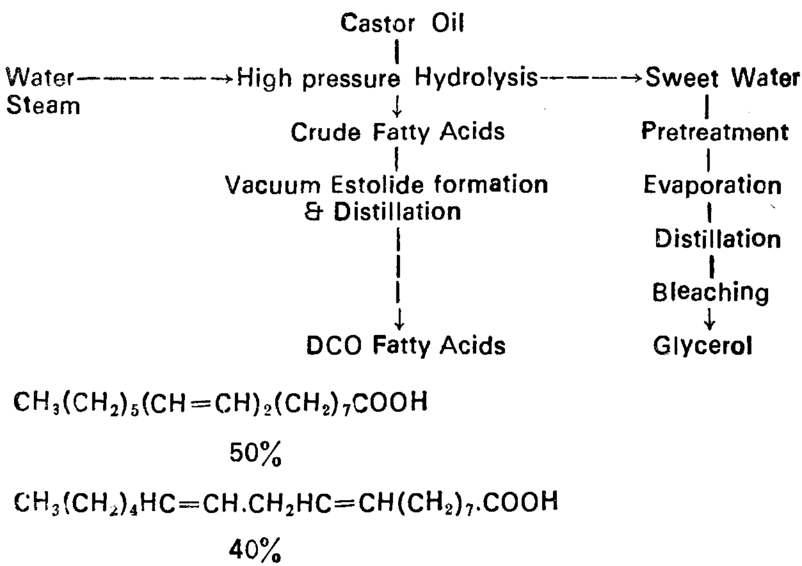


Fig. 9.11 Process Outline for DCO Fatty Acids

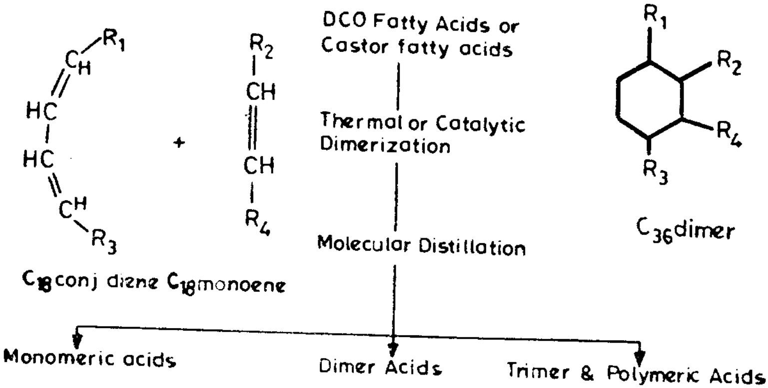


Fig. 9.12 Process Outline for Dimer Acids

$HOOCR_1COOHH_2NR_2NH_2$

Dimer acid + Difunctional amine ————————→ Heat under Vacuum

↓

$(OCR_1COH\ NR_2NH)_n$

Non-reactive polyamide

$HOOCR_1COOHH_2N\text{-}CH_2CH_2NH\text{-}CH_2CH_2NH_2$ → Heat under Vacuum

Dimer acid + Polyfunctional amine

↓

$OCRCONH\text{-}CH_2CH_2NH\text{-}CH_2CH_2NH$

Reactive polyamide

Fig. 9.13 Process Outline for Polyamides

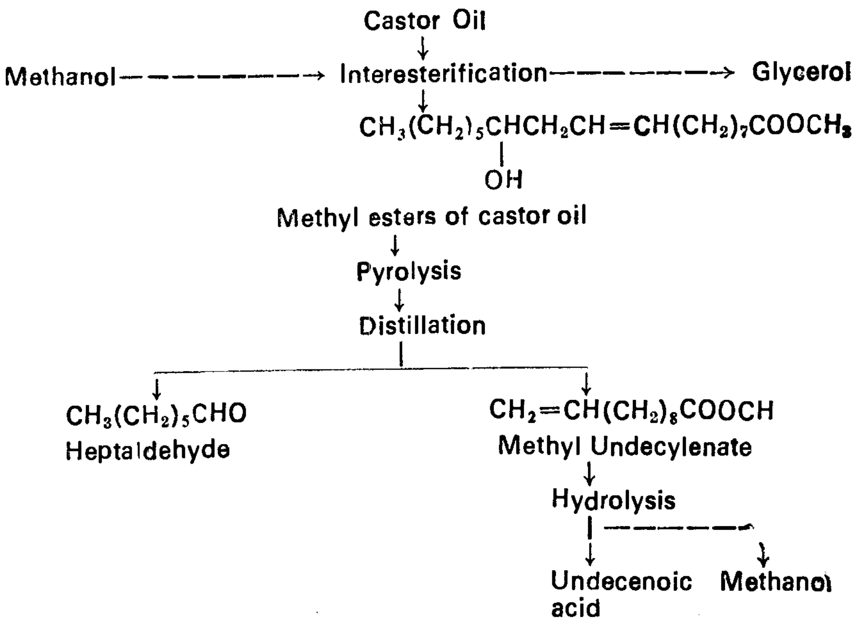


Fig. 9.14 Process Outline for Heptaldehyde and Undecenoic Acid

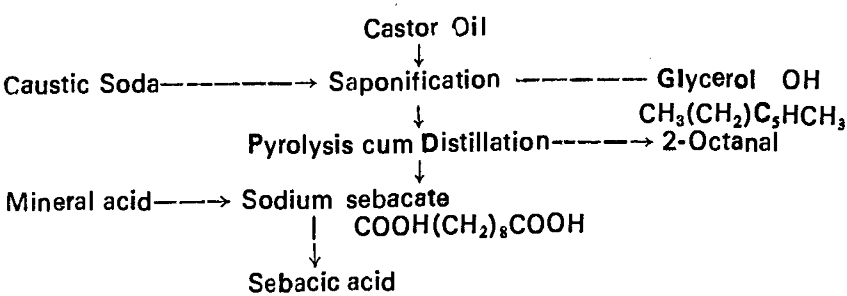


Fig. 9.15 Process Outline for Sebacic Acid and 2-Octanol

pulp and paper industries as its contains less than 19% lignin and 36-42% cellulose. The main stem of castor stalks can be gainfully used in rural housing as rafters. Combustible biogas of 48 l/kg can be produced even in winter season from castor shells which has 0.92% nitrogen, 0.91% potash and 0.98% phosphorus, showing its use as organic manure also. Data on yield of wheat with castor shell manure treatment is reported to be comparable with the yield available from the farm yard manure castor leaves have 2.73% nitrogen, 1.47% phosphorus and 0.78% potash which also shows a good potential for its use as manure.

Table 9.6 Proximate analysis of castor stalks and shells

Parameter	Castor Stalk	Castor Shell
Moisture content, %	11.03	11.33
Cellulose, %	37.63	22.81
Hemicellulose, %	8.74	43.50
Hollow cellulose, %	46.37	66.31
Acid detergent lignin, %	14.54	11.41
Acid detergent fibre, %	61.98	39.70
Neutral detergent fibre, %	69.72	54.91
Ash content, %	6.3	—
Average fibre diameter, mm	0.076	—
Average fibre length, mm	300.0	—

Ref : Bhai and Varshney, 1988

10. LINSEED

The linseed (flax) plant exists in two main varieties, one gives a high yield of seed and the other fibre. Dual purpose plants are reported to yield inferior seed and fibre. (TRDI. 1971). The plant thrives principally in warm temperate zones and like other vegetable oil plants, the degree of unsaturation of the oil is markedly influenced by genetic variety and seasonal changes in temperature and rainfall. Dry seed contains upto 45% oil, a distinguishing feature of which is the linolenic acid content of around 60%. This explains the principal use of this oil as a drying oil in the plant industry, where catalytic accelerators of oxidation may be included in formulations. India produces about 0.42 million tonnes of linseed over an area of approximately 1.5 million ha. This Chapter describes technology for storage, cleaning/grading, oil extraction and cake/meal utilization of linseed.

10.1 Cleaning and Grading

Pedal and power operated cleaners developed by CIAE, Bhopal are found suitable for linseed also. The specification of sieve, capacity and cost of operation of equipments are given below :

Pedal operated cleaner

Screen size, mm	:	Top screen — 1.6 × 20 Bottom screen — 2.0
Capacity, Kg/h	:	180
Purity, %	:	98.6
Cost of operation Rs/t	:	77.50

Power operated cleaner

Screen size, mm	:	Top screen — 1.6 × 20 Bottom screen — 2.0
Capacity, Kg/h	:	230
Purity, %	:	99.1
Cost of operation. Rs/t	:	56.50

10.2 Drying

If linseed seeds dry and ripen too far before being harvested, it may split, causing shedding losses in addition to losses occuring during harvesting. Linseed does not shed too easily but losses can easily occur during transport and drying because of its slippery nature. Traditionally sheaves of the harvested plants are left in the fields to dry. Now a days direct combine harvesting is employed often after chemical dessication. Seeds will dry quickly to 15·25% moisture even to 10% in hot weather. Lin heated air may be used down to 14% moisture content, thereter warm air must lower the moisture content to 10%.

10.3 Storage of Seed

Linseeds can be stored at domestic level in an airtight clean structure once its moisture is brought down to 6-8%. Temperature in the house where the storage structure is kept should not exceed 35°C. Proper cleaning is essential before stotage of linseeds.

Studies conducted at JNKVV, Jabalpur for storage of linseeds in gunny bag, baked earthen pitcher (mud plastered outside) and plastic containers have shown that maximum infestation takes place in gunny bags where webbed masses of seeds of 2.3-10 g weight are formed. Infestation, is caused by fig, moth, *cadna Cauellla*, rice moth etc. The oil content of seed varies between 38.9 to 40% in gunny bags, 38.5 to 40% in baked earthen pitcher and 39 to 40% in plastic containers. With increase in moisture level and storage period, the FFA formation increases in all containers, more so in baked earthen pitcher, in the range of 2.7 to 5.7%. Figures 10.1 to 10.3 show the variations in oil, protein and free fatty acid contents of the linseed during 4 months storage in above mentioned storage structures.

10.4 Oil Extraction and Refining

The small seeds are usually pre-pressed and solvent extracted to obtain oil. In India, ghanies are used mostly for this purpose. Hulls, being comparatively low in fibre and rich in protein, remain in the cake

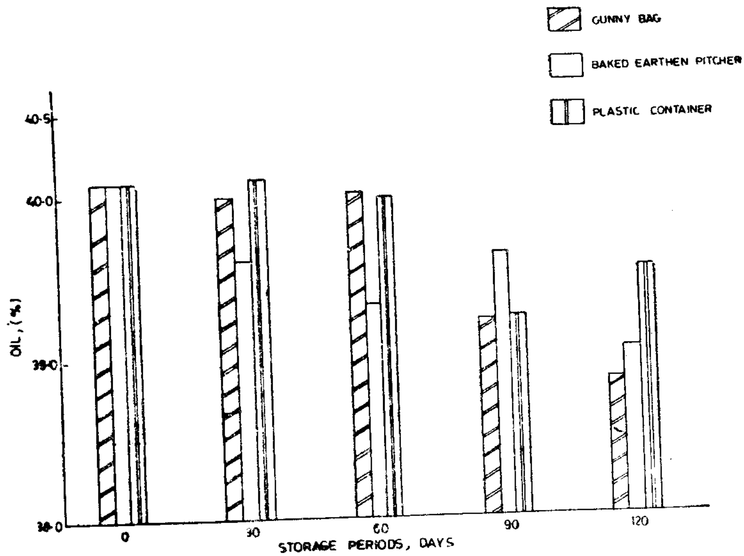
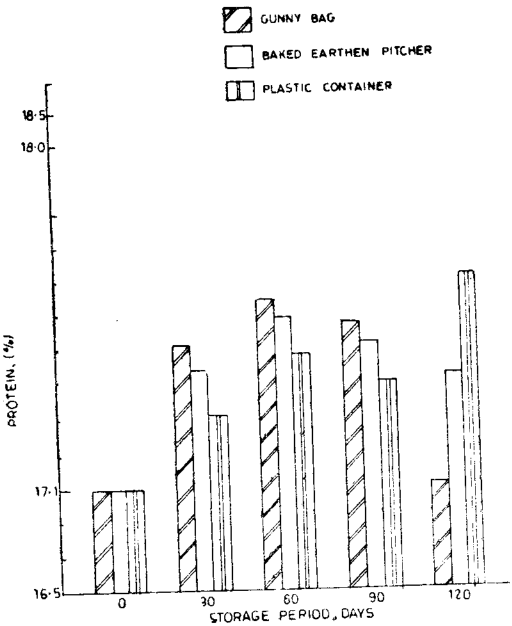


Fig. 10.1 Oil Content of Linseed in Different Storage Containers



Eig. 10.2 Protein Content in Linseed in the Different Storage Containers

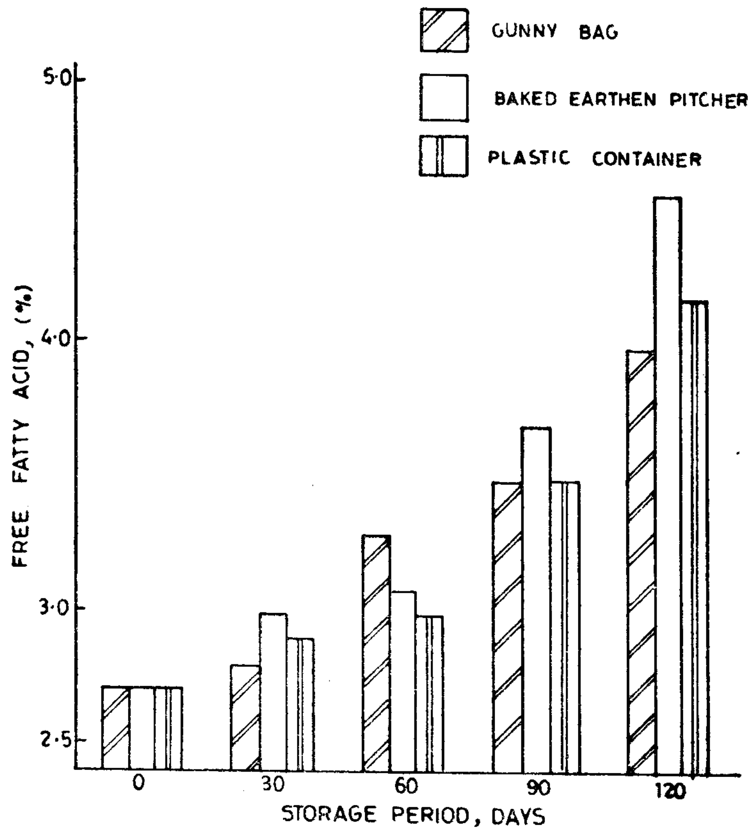


Fig. 10.3 Free Fatty Acid Content in Linseed Oil in the Different Storage Containers

meal. As the seed itself is very hard, it must be crushed or softened by boiling before being fed. Both gums and waxes occur in the crude oil, settling in tanks for upto three weeks allows 1% of the oil to separate and settle foats. Subsequently if the decanted oil is warmed rapidly to 110°C a further deposit of 0.5% takes place. Such treatment is long established and described as a break of the oil. Further degumming, neutralisation and washing may be based on the refining of soybean oil where the difficulties are comparable. Chilling may cause some further wax to separate and in any case upto 3% highly acid activated earth may be needed to lighten the colour to an accepatable standard. In handling and storing the oil due regards needs to be paid to its readiness to oxidise and even polymerise in air.

Studies have been conducted at CIAE, Bhopal for evaluation of Mini-40 screw press for extraction of oil from linseed. For this experiment, linseed samples were soaked in water for about 1 hour at room temperature and later dried to moisture levels of 5.7, 9 and 11 percent. Table 10.1 and 10.2 show the data of performance evaluation. It can be seen that these samples gave average oil yields of 69.80, 74.29, 73.89 and 62.39 percent at seed moistures of 5.31, 7.23, 9.10 and and 11.14 per cents respectively. It, thus, depicts that though oil recovery is low, yet sample having 9 percent moisture content yielded maximum of 74.29 percent oil yield. This phenomenon may be attributed to the fact that at 9 percent moisture level, the shear and compression are relativaly better than at other moisture levels. While low moisture causes bitteness, the higher moisture conten causes the plasticizing effect which reduces the level of comaression and gives poor recovery. In order to improve the oil recovery, the linseed was given water soaking treatment at room temperature and dried to 5.18, 7.29 and 9.08 percent moisture levels and crushed in expeller. The oil yields were 73.87, 81.62 and 68.95 percents respectively on these moisture levels. The expressed oil contains high gum content.

10.5 Cake/meal Utilization

The name lineseed meal is used normally for ground unextracted seed (35% oil), ground linseed cake (10% oil) and linseed meal (3% oil) from a solvent plant. Rich oil content can affect texture and flavour of meat and butter obtained. Immature linseed contains the enzyme linasi which releases prussic acid from the glucoside linamarin. To avoid poisoning cattle, the linasi must be inactivated by heat, 10 min. boiling of seed or cake is reported to ensure this (Gohl, 1975).

Table 10.1 Performance of mini 40 screw press with linseed
Treatment : Moisture conditioning.

Feed quantity, kg	Approx. M.C. of prepared sample, % (wb)	Passes	Clearance, mm	Time of crushing, mm	Total oil with particles in suspension, cc	Foots after 24 h, cc	Net oil yield, cc	Temp. at oil outlet, °C	Energy consumed, Kwh/kg	Oil recovery (total oil basis), %
1	5.31	I	1.0	6-35	205.00	96.70	108.30	101.7		
		II	0.4	6-37	165.30	65.00	100.30	101.0		
		III	0.4	8-33	62.30	18.30	44.00	116.7		
				21-45	432.60	180.00	262.60		0.622	69.80%
2	7.23	I	1.0	13-18	301.00	110.00	191.0	111.7		
		II	0.4	10-48	268.30	80.00	188.3	116.7		
		III	0.4	10-40	220.30	61.70	158.7	121.7		
				34-46	789.60	251.70	537.09		0.583	74.29%
3	9.10	I	1.0	11-00	397.30	133.30	264.0	101.7		
		II	0.4	12-09	278.00	103.30	174.7	116.7		
		III	0.4	13-44	165.00	68.30	96.7	121.7		
				36-53	840.30	304.90	535.40		0.558	73.89%
4	11.14	I	1.0	12-04	373.30	173.30	200.0	112.3		
		II	0.4	11-56	349.00	155.70	193.3	121.7		
		III	0.4	11-30	116.30	57.70	58.7	126.7		
				35-30	838.60	386.70	452		0.500	62.39

Table 10.2 Performance of Mini 40 screw press with linseed

Treatment : 1 h tap water soaking

Sample wt., kg	M. C., % (wb)	Passes	Clearance, mm	Time, min.	Sec.	Oil + foot, cc	Foots, cc	Net oil, cc	Temp., °C	Energy cons., Kwh/Kg	Oil yield total oil basis), %
1	5.18	I	1.0	8	19	154	70	84	103	0.15	76.5
		II	0.4	6	13	150	65	85	107	0.11	
		IIII	0.4	5	25	130	22	108	116	0.10	
		I	1.0	5	30	210	65	125	105	0.11	
		II	0.4	7	9	145	63	82	107	0.133	71.25
		III	0.4	6	21	83	32	51	112	0.10	
1	7.10	I	1.0	6	30	250	100	150	105	0.108	
		II	0.4	6	56	160	60	100	110	0.11	73.87
		III	0 4	6	34	80	40	40	115	0.10	
		I	1.0	6	10	246	110	136	105	0.11	
		II	0.4	5	59	210	75	135	110	0.10	83.13
		III	0.4	6	20	50	20	130	115	0.11	
2	9.08	I	1.0	7	15	310	160	150	105	0.13	
		II	0.4	6	3	125	90	35	110	0.11	65.00
		III	0.4	5	53	70	20	50	115	0.10	
		I	1.0	6	18	275	150	125	110	0.15	
		II	0.4	6	21	200	96	104	113	0.13	72.91
		III	0.4	6	29	105	70	35	118	0.13	

11. ECONOMIC GAINS AND EMPLOYMENT POTENTIAL IN PROCESSING OF OILSEEDS AT RURAL/FARMERS LEVEL

With reference to oilseed processing industry in India, this chapter describes at length, the prospects in terms of possible gains, net profits and employment potential on account of use of some selected post harvest equipment at farmers level. With the help of a few selected small scale equipment described in previous chapters, possible gains and net benefits to the farmers/processors by processing 7 major oilseeds produced in India is found to the tune of Rs. 23.5 billion and Rs. 18 billion per year, respectively. The primary processing of certain assumed percentage of these 7 oilseeds at rural (farmers/procssors) level is expected to generate 2.24 million man day employment per year. The cost economics reveals that 101% extra amount would be required through selecting the pathway of production of oilseed over processing in case of groundnut alone while this percetage works out to be 83% for rapeseed and mustard.

11.1 Agro Processing of Oilseeds

It is well known that Indian economy revolves to a considerable extent around agriculture and agro-based industries. As the two sustain each other, there is a great need for a sharperfocus on agro-based industries which would integrate employment and value-added generation, with more efficient use of land-based products optimised to the local agro-climatic and socio-economical conditions. To this effect introduction of small scale agro-processing industries which would not need large capital investments, would be within the reach of farmers and will be helpful in the overall development of the rural sector.

The processing of oilseeds consists of various unit operations viz. cleaning, grading drying, dehusking, decortication, size reduction, expelling, mixing, blending, packaging, storage, quality control, transport, marketing and by-product utilization. The unit opperations selected for on the farm processing or rural processing are cleaning and grading, drying, storage, stripping, decortication, shelling cum winnowing and oil extraction by power/bullock operated oil ghanies.

On selection of equipment for processing of oilseed at village level, efforts have been made to calculate the number of units required for processing of certain assumed fraction of selected oilseed. Calculations have also been made to know the total amounts to be invested in making available the desired number of equipment. Likely incremental returns to the farmers on account of value-adding or loss prevention have also been calculated, based on 1985-86 production figures and 1987-88 trendsin market prices. In order to show the profitability of such investment, likely returns have been compared with the amount of investment on equipment.

11.2 Potential of Additional Income by Processing Oilseeds at Farmer's Level

Table 11.1 shows the potential of earning additional income through the application of selected post harvest equipment for processing of oilseeds at farmer's level. The cropwise figures have been arrived through multiplying the production figures of an oilseed with the market rate, potential for additionai income and the percentage of oilseed processed. The gains have been calculated keeping in view either loss prevention as in case of storage structures or value addition or a combination of both. In case of storage period (from harvesting season to off-season) have also been considered as gain. In case of groundnut strippers, the saving of time has been considered as gain. and its monetary value if calculated based on wages of unskilled labourers. The Table 11.1 shows possible gains of Rs. 23.55 billion by processing (certain assumed fraction) of 7 oilseeds namely groundnut, rapeseed/mustard, soybean, castor, sunflower, linseed and saffiower.

11.3 Requirement of Small Scale and Low Cost Processing Equipment

Calculations for projected requirement of post harvest equipment towards processing feasible proportions of major oilseeds as shown in Table 11.2 reveals that a large number of selected equipment are

Table 11.1 Potential of additional income using selected post harvest equipment for processing of oilseeds at farmer/producer's level (rural sector)

mt = million tonnes
Rs-M = Rupees in million

Sl. No.	Oilseed	Production* ('85-86), mt	Market rate ("87 88), Rs/t	Post harvest operation to be used	Percentage of production to be processed	Potential of additional income, %	Possible gains by processing Rs.-M*
1.	Groundnut	5.5	8,000	Cleaner & grader	100	7.5	3,300
				Stripping	100	12.0	5,280
				Drying	50	10.0	2,200
				Decortication	25	12.5	1,375
				Oil extraction	25	22.0	2,420
				Storage**	25	16.0	1,760
2.	Rapeseed/ Mustard	2.6	6,500	Cleaning & grading	100	7.5	1,267.5
				Storage**	25	16.0	676.5
				Oil extraction	50	45.3	3,827.9
3.	Soybean	0.9	5,000	Cleaning & grading	100	7.5	337.4
				Storage**	40	16.0	288.0
4.	Castor	0.3	7,340	Shelling cum winnowing	75	6.0	99.0
5.	Sunflower	0.3	4,500	Cleaning cum grading	100	7.5	101.25
				Shelling	100	12.5	168.75
				Oil extraction	50	25.0	168.75
6.	Linseed	0.3	8,300	Cleaning & grading	100	7.5	186.75
7.	Safflower	0.3	4,150	Cleaning & grading	100	7.5	93.37
	Total :	10.2					23 549.77

* Cost of processing has not been substracted
** Grains on account of storage are through :
(a) reduction in avoidable losses, and
(b) average increase in value after 6 month storage period.

Si. No.	Cropwise equipment	Use period, d/y	Quantity of oilseed processed	Total production to be processed, mt %	Requirement of euipment, 000 units	Cost of the equipment, Rs.	Total cost of equipment, Rs–M
1.	Groundnut	–	5.5	–	–	–	–
1.1	Grader	30	–	100	38.19	5,000	190,95
1.2	Bindrier	50	–	50	68.75	9,500	653.13
1.3	Outdoor metal bin	180	–	25	440.0	6,000	2,640.00
1.4	Power operated stripper	30	–	100	229.2	6,000	1,375.00
1.5	Power operated groundnut decorticator	30	–	25	343.2	4.700	161.30
1.6	Power ghani	50	–	25	239.1	15,000	3,586.50
						Sub-Total :	8,606 88
2.	Rapeseed/Mustard	–	2.6	–	–	–	–
2.1	Pedel operated cleaner	30	–	100	18.05	3,000	54.15
2.2	Hapur bin	180	–	25	921.9	950	875.80
2.3	Power ghani	200	–	50	81.25	15,000	1,218.75
						Sub-Total :	2,148.70
3.	Soybean	–	0.9	–	–	–	–
3.1	Pedal operated cleaner	25	–	100	8.18	2,500	20.45
3.2	Hapur bin	180	–	40	510.63	950	485.09
						Sub-Total :	505.54
4.	Castor	–	0 3	–	–	–	–
4.1	Sheller cum winnower	50	–	75	22.5	8,000	18.00
5.	Sunflower	–	0.3	–	–	–	–
5.1	Power operated cleaner	20	–	100	5.43	4.000	21.72
5.2	Sheller	25	–	100	12.00	8,000	96.00
5.3	Powerghani	30	–	50	8.33	15,00	124.95
						Sub-Total :	242.67
6.	Linseed	–	0.3	–	–	–	–
6.1	Pedal operated cleaner	20	–	100	10.4	2,500	26.00
7.	Safflower	–	0.3	100	–	–	–
7.1	Pedal operated cleaner	20	–	100	5.95	2,500	14.87
						Grand Total :	11.562.66

required. Table 11.2 reflected the numerical values of the requirement for different equipment (cropwise). For example, the requirement of graders for 1985-86 production of groundnut was worked out to be 38.19 thousand units while for drier (for drying of 50% produce of groundnut), metal bin (for storage of 25% of groundnut production), power operated stripper for stripping of 100% produce) decorticator (for decortication of 25% produce) and oil ghani (for oil extraction from 25% produce) and oil ghani (for oil extraction from 25% produce) are 68.75, 440,229.2, 343 2 and 239.1 thousand units respectively. It may be noted that the estimated cost of purchasing these equipment in total could be to the tune of Rs. (11.56) billion (for all 7 oilseeds). It may, however, be further noted that the processing operations included in this study are only those for which low cost small scale processing equipment are available. Moreover, the processing operations include only the primary level and upto some extent secondary level processing of the available oilseeds. Food processing operations, involving higher degree of hygenic and quality standards are difficult to be maintained at small scale level by rural entrepreneurs and that is why they have been excluded from this study.

11.4 Benefits and Employment Generation Opportunities

Processing of above mentioned 7 oilseeds for the operations mentioned earlier involve certain costs, which are presented in Table 11.3. These figures have been derived by multiplying the unit cost of processing by an individual equipment with the total number of equipment required for processing of selected reasonable fraction of the oilseed produced. The processing of groundnut would involve processing cost to the tune of Rs. 3.86 billion per year for earlier mentioned unit operations. These costs are inclusive of valid costs viz. labour wages, electricity charges, break down, maintenance etc. and fixed costs, namely depreciation, cost of space, interest on working capital, preventive maintenance and overhead costs. The entire cost of processing all 7 major oilseeds at rural level was found out to be Rs. 5,508.14 million. These cost figures, as presented in Table 11.3, have been found for differen unit operation of all 7 crops individually and added together to determine above mentioned total cost of processing. Benefits on account of processing of the oilseeds have been worked out by deducting the cost of processing from possible gains on account of processing. It is revealed that net benefits could be to the tune of Rs. 18 billion per year The benefit to cost ratio reveal encouraging figures, ranging from 2.11 to 7.03 for sunflower and linseed respectively.

The possibie employment potential, on account of use of selected post harvest equipment for processing of 7 oil seeds has been also worked out (Table 11.3). These values are obtained by multiplying the number of mandays per year required for handling individual equipment with that of the total number of equipment required. The employment potential has been worked out for ail earlier mentioned selected unit operations, for all 7 oilseeds individually. Thus for all 7 oilseeds and their selected unit operation, the total employment potential would be 2.24 lakh mandays/year. Here it may be noted that the calculated employment potential is purely for operation of the equipment.Employment potential in manufacturing these equipment and marketing operations would be additional to these calculated figures. On increasing the number of operations through addition of other equipment, the employment potential may be further enhanced.

11.5 Processing and Production Pathways for Additional Gains

In order to find out the benefit to the farmers through processing or through additional production, analysis have been made as shown in Table 11.4 For this purpose, the cost of production of all 7 oilseeds and possible gains through post harvest operations on account of value addition have been considered. Processing gains have been equated with additional farm production by dividing the gains by the market price prevailing in 1987-88, for individual oilseeds. In case of groundnut, for example, it is revealed that the gains on account of processing were equivalent to 2.04 million tonnes of additional groundnut production for which an amount of Rs. 7,752 million would be required as cost of production. This is with the assumption that the incremental cost of operation follow a linear

Table 11.3 Benefits and employment generation by processing of oilseeds at farmer/processor level by use of selected small scale equipment

Sl. No.	Oilseeds	Post harvest operations	Possible gain by precessing, Rs. M	Cost of processing, Rs./t	Cost of processing, Rs. M	Benefits, Rs-M	Benefits to cost ratio, %	Employment opportunities, md/y × 10³
1	2	3	4	5	6	7	8	9
1.	Groundnut	(i) Cleaning & grading	3,300	24	132.00	3,168.00	24.00	76.38
		(ii) Drying	2,200	161	442.75	1,757.25	3.96	68.75
		(iii) Storage	1,760	500	687.50	1,072.50	1.56	
		(vi) Stripping	5,280	212.5	1,168.75	4,111.25	3.51	916.60
		(v) Decortication	1,376	39.5	54.31	1,320.69	24.31	686.40
		(vi) Oil extraction	2,420	1000.0	1,375.00	1,045.00	0.76	239.10
		Sub-Total	16,335		3,860.31	13,474.69	3.23	1,987.23
2.	Rapessed & Mustard	(i) Cleaning & grading	1,267.50	14	36.40	1,231.10	33.82	36.10
		(ii) Storage	676.00	450	292.50	383.50	1.31	—
		(iii) Oil extraction	3,287.90	790	1,027.00	2,800.90	2.72	81.3
		Sub-Total	5,771.50	—	1,355.90	4,415.5	3.25	117.4
3.	Soybean	(i) Cleaning & grading	377.50	14	12.60	324.90	25.78	16.36
		(ii) Stornge	288.00	250	90.0	198.00	2.20	—
		Sub-Total	625.50	—	102.6	522.8	5.09	16.36

1	2	3	4	5	6	7	8	9
4.	Castor	Shelling cum winnowing	99.00	59.5	13.38	85.62	6.39	45.00
5.	Sunflower	(i) Cleaning & grading	101.25	37.0	11.10	90.15	8.12	10.16
		(ii) Shelling	168.75	181.5	54.45	113.30	2.08	24.00
		(iii) Oil extraction	168.75	500.0	75.00	93.75	1.25	8.23
		Sub-Total	438.75	—	140.55	287.20	2.11	43.19
6.	Linseed	Cleaning & grading	186.75	77.5	23.25	163.50	7.03	20.8
7.	Safflower	Cleaning & grading	93.77	40.5	12.15	81.22	6.68	11.9
		Grand Total	23,549.77	—	5,508.74	18,040.63	3.27	2,241.88

t=tonne, M = Million and md/y=mandays/year

Table 11.4 Gains from processing compared with the cost of processing and cost of production for equivalent gains

S. No.	Items	Cropwise Details						
		Ground-nut	Repe-seed & Mustard	Soybean	Castor	Sunflower	Linseed	Safflower
1.	Possible gains by post harvest operation, Rs.-M	16,335	5,771.40	625.50	99.0	438.75	186.75	93.37
2.	Market price, Rs/t	8,000	6,500	5,000	7,340	4,500	8,300	4,150
3.	Cost of production (estimated), Rs./t	3,800	2,830	2,749.00	2,880	3,398	2,636	3,214
4.	Returns as equivalen to production volume (mt) (1% 2)	2.04	0.88	0.12	0.013	0.097	0.022	0.022
5.	Cost of processing, Rs.-M	3,680.31	1,355.9	102.60	13.38	140.55	23.25	12.15
6.	Total cost of production of (4) = (4) × (3) Rs.-M	7,752.0	2,490.4	334.8	37.44	329.60	57.92	70.70
7.	Retio of cost of production of pronessing gains to cost of processing, (6) % (5)	2.01	1.83	3.26	2.79	2.34	2.49	5.81

relationship. The ratio of the cost of production (equivalent to processing gains) to the cost of processing reveals that the values are always more than unity which in other words mean that it is advantageous to process the oilseeds as compared to investment for increasing the production. These values are in the range of 2.01 for groundnut, 1.83 for rapeseed and mustard, 3.26 for soybean, 2.79 for castor, 2.34 for sunflower, 2 49 for linseed and 5.81 for safflower. Thus for groundnut the ratio of 2.01 reveals that for certain additional gains, a farmer could have spent 101% more by selecting the pathway of production as compared to processing.

11.6 Summary

The persistent gap of demand and supply can not be abridged in the absence of a strategic achievement in production and productivity through cultivation as well as processing, operations, imports being only a short term solution.

Market trends reveal thet processed products fetch higher price on sale as compared to the raw materials. A study conducted at CIAE, Bhopal reveals that ahout 30 equipment have been developed by various R & D organizations in India for small scale processing of oilseeds. These include cleaners, grades, dryers, decorticators, strippers, storage structures and oil extraction units. These equipment need low investment and can be operated successfully at the farmers/processors level for on the ferm processing of oilseeds. These equipment need unskilled or semi skilled man power for their operation, hence the fixed cost and over heads are also minimized.

With the help of selected equipment used for processing of certain assumed fractions of the 7 major oilseeds produced in India in 1985-86 possible gains could be to the tune of Rs. 23.5 billion per year. It is also revealed for this purpose that the entire cost could be met over a number of yeats. The monetary value of the cost of processing is calculated to be Rs. 5.5 billion per annum. Sale of the processed products would generate net benefits for the farmers to the tune of Rs. 18.0 billion per year. The benefit cost analysis of selected processing operations reveals overall profitability for ths farmer, for example, the analysis reveals that 101 per cent extra amount would be required through selecting the pathway of production as compared to processing pathway in case of groundnut alone. The possible employment potential on account of using the selected post hervest equipment for processiug of seven major oilseeds of India has been worked out to be 2.24 million mandays, per year, which is purely for operation of the equipment, not accounting the employment potential in manufacturing these equipment and their maketing operations.

BIBLIOGRAPHY

1. Alam A. 1988. Post harvest processing and technologies towards increasing oil productivity. In: Proc. Nat. Sem. On Strategies for Making India Self Reliant in Vegetable Oils. DOR. Hyderabad Sept. 5-9.

2. Alam A. and N. Ali. 1986. Mini solvent extraction plant for exploitation of oblegeaneous products and by-products in rural sector. Nat. Sem. on Oilseeds Products for Edible Purpose, HBTI, Kanpur, March 1-2.

3. Ali, N. 1988. Strategies for increasing oil productivity through post-harvest processes and technology In: Proc. Nat. Sem. On Strategies for Making India Self Reliant in Vegetable Oils. DOR, Hyderabad, Sept. 5-9.

4. Ali. N, A.P. Gandhi and A. Alam. 1985. Processing and Utilization of Soybean. Proc. ISAE-SJC. 3 (2).

5. Ali N, A.P. Gandhi and T.P. Ojha 1988. Soybean Processing and Utilization in India. Proc Nat. Sem. Soybean Processing and Utilization in India Tech. Bull. No. CIAE/SPU-1/88/53, CIAE, Bhopal.

6. Agrawal, Y. C., A. K. Tikkoo BPN Singh and M. Narain. 1987. Post harvest technology of oil seeds problems and prospects. Paper PAS-87-021, XXIII Annual Convention ISAE, JNKVV, Jabalpur, March 9-11.

7. Anon, 1990. SEA Handbook. The Solvent Extraction Association of India, Bombay.

8. Arya, S.S, K. Vidya sagar, K.S Premvati and B.D Parihar. 1976. Chemical changes in refined oil during storage and during operation In: Proc. Svmposium on Fats and Oils in Relation to Food Products and Their Preparations. CFTRI, Mysore June 3-4.

9. Azeemoddin, G. 1989. Use of sunflower seed and oil. Oilseeds News Letter 11 (11-12), Jan.-Feb.

10. Bhatnagar, A.P 1976. Techno-economic survey for the development of oilseeds industry in Punjab Vol. I PAU, Ludhiana.

11. Berger, WM 1981, Handling, transport and preparation of soybean. J. Am oil Chem. Soc. 58 : 489.

12. Blagdyr A P. edd L.B. Sevastayanora 1975. Changes in sowing Quality of Sunflower and castor seed stored under low temperature Selek. i. Semen : 59.

13. Bredson D K. 1976 Mechanical pressing, J. Am Oil Chem. Soc. 54 : 489.

14. Breson DK. 1983 Mechanical Oil Extraction. J. Am Oil Chem Soc. 60 (2).

15. Cobb. W., S Gillilans and E. Williams, 1969. Chemical and microbiological chnnges in stored uncured peauuts. Food Tech 23 : 1586.

16. Dakshinamurthy. A and N. Ali 1984, Studies on farm level and bulk storage of soybean seed. Project Report No. PH/B/81/3 CIAE, Bhopal.

17. Daun, J.K and L.D. Burch, 1984. Oilseed grading quality control in oilseeds marketing, Ibid. 61 : 117.

18. Galloway J.P. 1976 and cleaning, cracking, dehulling decorticating and flaking of oil bearing materials, ibld 53 : 271.

19 Duffuss, C M. and J. C. Slaughter, 1980. Seeds and their uses. John Willey Sons, Chichester, Newyork : 142-145.

20. Gohl, B O. 1975 Tropical feeds. FAO, Agricultural Studies. No. 96 FAO. Rome.

21. Good. R D. 1967. Raw materials handling and control J. Am Oil Chem. Soc. 44 : 242.

22. Gustafson, E H. 1976 Loading, unloading, storage, drying and and cleaning of vegetable oil bearing materials. J. Am oil chem. Soc. 53 : 248.

23. Gustafson, E H. 1978 Raw materials handling and control J. Am Oil Chem. Soc. 55: 751.

24. Gandhi A P. and N. Ali 1988 Simple technologies for making some soybased products. In : Soybean Processing and Utilization in India CIAE, Bhopal.

25. Jackbson, L A. and L F. Backer 1986. Recovery of sunflower oil with a small screw expeller. Energy in Agriculture. 5 : 199-209.

26. Janson I.I. 1974. Castor oil production UNIDO Publication, ID/125, Newyork.

27. Jayaraman, S.T.S. Vasundhara and D.S Parihar. 1976. PVC bottles as storage media for edible oils In : Proc. Symp. On Fats ann Oils in Relation to Food Products and Their Preparations CFTRI, Mysore, June 3-4.

28. Kachru, R.P, P.K. Srivastava, B.S. Bisht and T.P. Ojha. 1986. 100 Bankable post harvest equipment developed in India, CIAE, Bhopal.

29. Khan, L.M. and M.A. Hanna. 1983. Expression of oil from seeds—a review. J. Agril. Engg. Res. 28 : 495-503.

30. Khan, L M and M A Hanna. 1983. Expression of Soybean oil. Trans ASAE. 27 (1) : 190-194.

31. Kulkarni D.N, M.S. N Rao and U.M. Ingle. 1988 Nutritional and processing aspects of edible grade meal from available cultivators of safflower In Proc. Nat Sem. On Strategies for Making India Self Reliant in Vegetable Oils. DOR, Hyderabad, Sept. 5-9.

32. Kulkarni, D N, N V. Joglekar and UM. Ingle. 1984. Processing of safflower meal. In : Proc. Symp. On Oil Seed Production and Utilization Constraint and Opportunities. Hindustan Lever Research Foundation, India.

33. Kumar, KR. A Magappan and DR. Bal. 1989. Evaluation of flexible packages to contain mustard oil J. Food. Sci and Tech. 26 (2) : 59-63.

34. Kundu. MK, 1990 Trends and prospects of vegetable oils. Souveneir XXVI Annual Convention ISAE, HAU, Hissar. Feb. 7-9.

35. Lakshminarayana. G. and AB. Afzalpurkar. 1988 A review of oil seeds processing technologies developed/being developed at RRL, Hyderabad. In : Proc. Nat. Sem. On Strategies for Making India Self Reliant in Vegetable Oils. DOR, Hyderabad, Sept. 5-9.

36. Lakshminarayana G. and HS. Rao. 1988. An overview of significant oil based products and processes developed at RRL Hyderabad. In : Proc. Nat. Sem. On Strategies for Making India Self Reliant in Vegetable Oils DOR, Hyderabad, Sept. 5-9.

37. Langstraat A. 1976 Characteristics and compositions of vegetable oil bearing materials. IBID. 53 (241).

38. Nag. KN. P Singh and R. Bhandari, 1983. A Centrifugal impeller type of sunflower seed decorticator. AMA : 55-58.

39. Nag, T.K. 1982. Portable pwer ghani. KVIC. Bombay.

40. Nash, MJ. 1978 Crop conseruation and storage in cool temperature climates. Pergamon Press, Oxford.

41. Nath, S. 1983. Decade of post harvest technology (1972-82). Post Harvest Technology Centre, IIT Kharagpur.

42. Othmer. D F. and J C. Agrawal. 1955. Extraction of soybean, theory and mechanism. In Khan and Hanna 1983.

43. Pandya, A C. N. Ali and A. Alam 1980. Post harvest technology in India, CIAE, Bhopal.

44. Parpia, HAB. 1980. Oilseeds proteins for human consumption. In : Proc Nat. Sem. On Strategies for Making India Self Reliant in Vegetable oils, DOR, Hyderabad, Sept. 5-9.

45. Patil, R T. and N. Ali. 1989. Small scale soybean processing equipment developed in India. CIAE, Tech. Buil No. CIAE/SPU-1 (89)/89. CIAE, Bhopal.

46. Patil R T. 1988 Equipment and techniques for processing of soybean at rural level. Proc. Nat. Sem. Soybean Processing and Utilization in India. CIAE Tech. Bull No. CIAE/SPU-1/88/53.

47. Patterson, HBW. 1989. Handling and storage of oilseeds, oils, fats and meal. Elsevier Applied Science Pub. London and New York.

48. Prinsloo, M and F J C. Huge, 1981. On farm sunflower oil extraction for fuel purpose. In : 3rd Int. Conf. Energy Use Management, Berlin, FRG : 1775-1782.

49. Rao, M V. 1987. Status of vegetable oil economy in India and role of technologies in solving oil shortage. J. OTAI 19 (2): 26-27.

50. Rao, M V, 1988. Short term and long term strategies for making India self reliant in vegetable oils, In : Proc. Nat. Sum. On Strategies for Making India Self Reliant in Vegetable Oils. DOR, Hyderabad, Sept. 5-9.

51. Sankar, R D. and K. Acharya : 1969. Occurrence and possible protective function of carbon dioxide. In Oilseeds, J. Sci. fd. Agric. 20 531.

52. Sarpeshkar, A M, D G. Prabhanjan and R. Ramaian 1988 Power operated sunflower thresher paper. Nat. Sem. On Strategies for Making India Self Reliant in Vegetable Oils, DOR, Hyderabad, Sept. 5-9.

53. Sawant, A R. and B M. Moghe 1985 Breeding research on safflower in Madhya Pradesh. In Proc. Second Oil Crops Network W/S, Hyderabad. Sept. 5-9, 1988.

54. Shenoi, P V. 1990 Present status of oilseed processing industry in India, Address at XXVI Annual Convention of ISAE, HAU, Hissar, Feb: 7-9.

55. Shukla, B D. 1988. Storage conditions and structures for oilseeds. In : Proc. Nat. Sem. On Strategies for Making India Self Reliant in Vegetable Oils, DOR, Hyderabad, Sept. 5-9.

56. Shukla B D. and S S. Mandivikar. 1986 Groundnut decorticator for seed production. Nat. Seminar cum Workshop on Agricultural Machinery for Production of Oilseed Crops, CIAE, Bhopal Dec. 30-31,

57. Singh, J. 1983 Performance, evaluation of KVIC power ghani. J. Ag. Engg. 20.

58. Singh J. 1984, Evalution of performance of rural ghani. J. Ag. Engg. 26 (2) : 147.

59. Singh, J. 1986. Oil expression from a thin bed of rape seeds (Brassica campestris) under uniaxial compression with constant load Ph.D Thesis (Ag. Engg.), GBPUAT, Pant Nagar.

60. Singh, J. 1988. Extrusion as a preparatory operation of soybean for expression of oil. A. E. T. 12 (5 & 6) : 10.

61. Singh J. P C. Bargale and L K. Sinha. 1989. Development of a power operated dehuller for soybean U. Oleagineux (Paris) 45 (5) : 231.

62. Singh J. T: Kapur and N. Ali 1981. Edible oil milling technology in India Tech. Bull., CIAE, Bhopal.

63. Singh, J. and B P N. Singh, 1985. Effect of moisture on oil yield from rapeseed. In Proc. Silver Jubilee Conv. ISAE, CIAE, Bhopal Oct. 29–31, Singh J. and B D. Shukla, 1991. Post Harvest Technology of Oilseeds CIAE, Bhopal.

64. Singh, J. and L K. Sinha 1990. A low cost dehuller for soybeans. Int. J. Fd. Sci. & Tech, U. K. 25 : 458.

65. Sosulski, F. 1979 Food uses of sunflower proteins. J. Am. Oil Chem. Soc. 56 : 438-442.

66. Srinivas Gopal, TK, RM. Parameshuriah, KG. Ghosh and TR. Sharma 1976. A packaging system for storage and transportation of refined groundnut and hydrogenated oil. In Proc. Symp. On Fats and Oils in Relation to Products and Their Preparations, CFTRI, Mysore June 3-4.

67. Srivastava, PK. 19 : Food uses of sunflower/safflower meals. CIAE, Bhopal.

68. Srivastava, PK. 1991. Status of small scale oil expelling system in India. Presented in 2nd Coordination Committee Meeting of Oilseed Processing Network, HBTI, Kanpur, Jan. 31-32.

69. Srivastava PK, RK. Gupta and BD. Shukla and SP. Singh 1990. Studies on Storage and packaging of crude groundnut and mustard oils. In Proc. XXVI Annual Convention ISAE, HAU, Hissar, Feb. 6-9.

70. Srivastava, PK, RK. Gupta and BD. Shukla. 1990 Extraction of oil from sunflower with a small screw expeller In : Proc. XXVI Annual Convention ISAE. HAU, Hissar Feb. 7-9.

71. Srivastava PK, RK. Gupta and BD. Shukla, 1988. Economic gains and employment potential in processing oilseeds at rural/farmers level. In Proc. Nat. Sem. On Strategies for a Making India Self Reliant in Vegetable oils. DOR, Hyderabad, Sept. 5-9.

72. Stein, W. and FW. Glaser, 1976 Continuous solvent extraction of sunflower seed, groundnuts, palm kernels, rapeseed and copra. J. Am. Oil Chem. Soc. 53 : 283.

73. Stokes, R. and LM. Reid, 1956. Handling, shipping and storage of oilseeds. J. Am. Oil. Chem. Soc. 33 : 453.

74. Swern, D. 1979. Bailey's industrial oil and fat products. Vol. I Fourth Edn. Hohn Wiley and Sons, Newyork.

75. Tikkoo, AK, DK. Gupta and BPN. Singh. 1985 Cold pressing of rapeseed. Res. Bull. PHT, Pant Nagar.

76. Tindale, LH. 1976. Current equipment for mechanical oil extraction. J. Am Oil. Chem. Soc. 53 : 265.

77. Thompson, JC. and CL. Peterson 1982. An automated small scale oil seed processing plant for production of fuel for diesel engines. In Proc. Int. Conf. Plant and Vegetable Oil as Foods and Forage ASAE, Aug. 2-4.

78. Ward. JAL. 1976. Processing high oil content seeds in continuous screw press J. Am. Oil. Chem. Soc. 53 : 261.

79. Wilson, D. and E. Jay 1976. Effect of controlled atmosphere storage on afflatoxin production in high moisture peanuts groundnuts. J. Stored Products Res. 12 : 97.

WORD INDEX

APPENDICES

Manufacturers of Oil Seed Processing Equipment in India

1. Groundnut Threshers

1.1 M/S Aruna Industries, Plot No. 119 B Industrial Complex, Kattedan, Hyderabad, 500252 (A.P.)

1.2 M/S Karshak Industries, Chatrinaka, Lal Darwaza, Hyderabad – 500253 (A.P.)

1.3 M/S Paras Engg. Works, Old Motor Garage, Behind Hospital Rajula, Distt. Amreli (Gujarat)

1.4 M/S Union Forging, Focal Point, Sherpur, GT Road, Ludhiana

2. Groundnut Decorticator.

2.1 Arasu Engineering Works, 467 Selvapuram, Siruwani Main Road, Coimbatore (T.N.)

2.2 A.P. Stae Agro–Industries, Development Corporation Ltd., Agro-Bhavan, 10-2-3 AC Guards, Hyderabad - 50004 (A.P.)

2.3 Dandekar Brothers, Shivaji Nagar, Sangli, Maharashtra

2.4 Dinesh Kumar Engg. Works, 41, Tudiayalur Main Road, Idigarai Post, Coimbatore

2.5 Elseetee Ubdystures, Trich, Road, Singanoollur, Coimbatore - 641005 (TN)

2.6 Fine Fabrication Works, Plot No. 211, Sector C Indrapuri, Bhopal - 462022 (M.P.)

2.7 Francis D'Souza and Co., Dahanu Road, P. B. No. 14, Thane (M.S.)

2.8 Great Eastern Engg. Co. 23, Mooker Nallancuthy. St., Madras - 600001 (T.N.)

2.9 Gujarat Agro Industries Corp. Ltd., Agro Service Div., Juhapura, Sarkhej Road, Ahmedabad - 382305 (Gujarat)

2.10 Hindoson Pvt. Ltd, The Lower Mall, Patiala - 147001 (Pb.)

2.11 Kirloskar Brothers Ltd., Lidyog Bhavan, Tilak Road, Pune - 9 (M.S.)

2.12 Kishan Engg. Works, Industrial Estate, Saharanpur, Nizamaabad (A.P.)

2.13 Mahakali Seving Machine and Iron Works, Station Road, Dahegam, Ahmedabad. 382305 (Gujarat)

2.14 Maruthamalai Andavar Industries, Gokulam Colony, PN Pudur, Coimbatore - 641041 (T.N.)

2.15 M.P. State Agro-Industrial Development Corporation, Panehanan Building, Malviya Nagar, Bhopal - 462003 (M.P.)

2.16 Solanki Loha Laghu Udyog Kendra, Railway Station Road, Rau, Indore (M.P.)

2.17 Sundaram Industries, Idigarai, Main Road, Idigarai, Coimbatore - 641031 (T.N.)

2.18 Union Forgings, GT Road, Sherpur, Ludhiana (Pb.)

2.19 Venkatesh Foundry, Gollapudi, Vizaya Wada (A.P.)

2.20 Valampuri Industries, 1–B Thiyagi Kumaran, St. P.N. Pudur, Coimbatore 641041 (TN)

3. Dryers

3.1 G G. Dandekar Machine Works Ltd., Bhiwandi Road, Thane (M.S.)

3.2 Thermax Pvt., Ltd., (Agril. Dept.), Thermax house, 4, Bombay Pune Road, Shivaji Nagar, Pune (M.S.)

3.3 Wanson (India) Pvt. Ltd., (Agril. Div.) Chinchwada, Poona (M.S.)

3.4 Damodar Engineers, 12, North Road, Calcutta (W.B.)

3.5 Lakshim Engg. Works, Plot G. Jawahar Auto Works, Vizaywada (A.P.)

4. Oil Expellers and Ghanies.

4.1 Kisan Krishi Yantra Udyog, 64. Moti Bhawan, Collector Ganj Kanpur - 208001

4.2 Directorate of Village Oil Industries, Khadi and Village Industries Commission, Gramodaya, Irla Road, Vile Parle (W) Bombay - 400056

4.3 Ambar Saranjam Bhandar, Ram Kumar Mill Compound Saraspur, Ahmedabad, Gujarat

4.4 Tamilnadu Small Industries Corporation (TANSI) NO : 1, Whites Road, Madras - 14 (T.N.)

4.5 Shankar Steel Industries, Samir Takiya, Gaya, Bihar

4.6 Trivedi Industries, 10, Industrial Estate Patna, Bihar

4.7 Maharashtra Engg. Works, 107, Bhudhwar Pet, Panjariapole Sholapur, Maharashtra

4.8 Vivek Engineers, Mapos Road, Vellore, Tamil Nadu

4.9 Nahan Foundry, Nahan, Himachal Pradesh

4.10 Alfa Engg. Works, Bombay

4.11 Manjit Engineering Company, Hapur Road, Ghaziabad

4.12 Balaji Rolling Shutters and Engg. Works, A-1-1-78, Charminar Chourasla, Hyderabad, 500020 (A P)

4.13 S P Engg. Corp., P. B. No. 218, 39 Factory Area, Kanpur

4.14 S P Foundaries, Kanpur

4.15 United Oil Mills Machinery Spares Pvt. Ltd., New Delhi

4.16 M/S Bharat Industrial Corporation, Bombay

4.17 M/S Tiny Tech. Plants Pvt. Ltd., Near Bhaktinagar Station Tagore Road, Rajkot 360002 (Gujarat)

5 Solvent Extraction Plants, Refineries, Oil Mills and Vanaspati Plants

5.1 Desmet India Pvt. Ltd., Shree Niketan, P Block, Shiva Nagar Estate, Dr. A. B. Road, Warli, P B No. 16582, Bombay (MS)

5.2 Vulcan Lavel Ltd , 7-A Sir PM Road, Bombay 400001

5.3 Troika Processes Pvt. Ltd. 607, Embassy Centre, Nariman Point Bombay 400021

5.4 Soveg. Engineers Pvt. Ltd., Martin-Coop. Housing Soc. Ltd., Mahim. Bombay 400016

5.5 Pennwalt India Ltd., 507 Kakad Chambers 1.32, Dr. A. B. Road, Worli, Bombay 400018

5.6 Oilex Engineers (India) Pvt. Ltd., 15, Neelkanth Commercial Complex, Chembur Gooandi Road, Chembur, Bombay 400071

5.7 Mecpro Consultants Pvt. Ltd., 610, Som Datt Chambers II Bhikaji Cama Place, New Delhi 110066

5.8 Eurrestra Industries Ltd., 11th Floor Tulsiani Chambers, Nariman Point, Bombay 400021

INDIAN STANDARDS ON OIL MILLING INDUSTRY

Sl. No.	Specifications	Standards for	Reaffirmed year
1.	**Oil Seeds.**		
1.1	IS : 3579-1965	Methods of test for oilseed	1981
1.2	IS : 4115-1967	Methods of sampling of oilseed	1981
1.3	IS : 4427-1967	Grading for groundnut kernells for oil milling and for table use.	1981
1.4	IS : 4428-1967	Grading for mustard seeds for oil milling	1981
1.5	IS : 4429-1967	Grading for sesamum seeds for oil milling	1981
1.6	IS : 4617-1968	Grading for linseed for oil milling	1981
1.7	IS : 4618-1968	Grading for castor seeds for oil milling	1981
1.8	IS : 4619-1968	Grading for mahua kernels for oil milling	1981
1.9	IS : 4620-1968	Grading for cottonseeds for oil milling	1981
1.10	IS : 5292-1969	Grading for safflower seeds for oil milling	1981
1.11	IS : 5293-1969	Grading for niger seeds for oil milling	1981
1.12	IS : 5294-1969	Grading for kusum seeds for oil milling	1981
1.13	IS : 5686-1970	Code of practice for handling and storage of oilseeds	1981

1.14	IS : 6220-1971	Grading of copra for table use and for oil milling	1981
1.15	IS : 7787-1975	Grading for neem kernel and depulped neem seeds for oil milling	1981
1.16	IS : 7797-1975	Grading for soybean for oil milling	1981
1.17	IS : 7798-1975	Grading for suuflower for oil milling	1981
1.18	IS : 8428-1977	Grading for karanja seeds for oil milling	1983
1.19	IS : 8443-1977	Grading for tobacco seeds for oil milling	1983
1.20	IS : 8557-1977	Grading for kokum kernels for oil milling	1983
1.21	IS : 9993-1981	Grading for Dhupa kernel for oil milling	1983
1.22	IS : 10006-1981	Grading for Nahar kernel for oil milling	1983

2. Oils Fats.

2.1	IS : 75-1973	Linseed oil. raw and refined	1984
2.2	IS : 435-1973	Castor oil	1984
2.3	IS : 542-1968	Coconut oil	1987
2.4	IS : 543-1968	Cottonseed oil	1987
2.5	IS : 544-1968	Groundnut oil	1987
2.6	IS : 545-1984	Mahua oil	1987
2.7	IS : 546-1975	Mustard oil	1987
2.8	IS : 547-1968	Sesamum oil	1987
2.9	IS : 3448-1984	Rice bran oil	1987
2.10	IS : 3490-2965	Nigerseed oil	1987
2.11	IS : 3491-1965	Safflower oil	1987
2.12	IS : 3492-1965	Karanja oil	1987

2.13	IS : 4055-1966	Maize (Corn) oil	1987
2.14	IS : 4088-1966	Kusum oil	1987
2.15	IS : 4276-1977	Soybean oil	1987
2.16	IS : 4277-1975	Sunflower oil	1987
2.17	IS : 4765-1957	Neem kernel oil and depulped neem seed oil	1987
2.18	IS : 5614-1970	Tobacco seed oil	1987
2.19	IS : 5637-1970	Water melon seed oil	1983
2.20	IS : 7375-1979	Sal seed fat	1986
2.21	IS : 8323-1977	Palm oil	1983
2.22	IS : 8591-1977	Kokum fat	1986
2.23	IS : 8879-1978	Dhupa fat	1986
2.24	IS : 8896-1978	Nahar oil	1985
2.25	IS : 8881-1978	Khakha fat	1985
2.26	IS : 9231-1979	Mango kernel fat	1986
2.27	IS : 9955-1981	Rubber seed oil	1987
2.28	IS : 10633-1986	Vanaspati	
2.29	IS : 11068-1984	Criteria for edibility of oils and fats	
2.30	IS : 11069-1984	Glossary of terms relating to oils and fats	
2.31	IS : 545-1968	Specification for mahua oil	
2.32	IS : 3472-E-1966	Solvent extracted cotton seed oil	
2.33	IS : 3471-E-1966	Solvent extracted coconut oil	

3. Genaral

3.1 Code of practice for control of Aflatoxin in groundnut (IS : 9071-1979)

(a) Part-I Harvesting, Transport & Storage or Groundnuts

(b) Part-II Plant storage & Processing flour and oil

ERRATA

Page 1	Para 2	Line 3	Table/Fig. 4	Read 5	In place of 6
1	3	1	–	rapeseed/mustard	rapes seed mustard
1	3	2	–	rapeseed/mustard	rapeseed mustard
1	3	7	–	Sunflowcr	Sunfower
2	1	2	–	existing	exists
2	2	5	–	availability of	availability
3	1	12	–	value of	value
3	2	3	—	in exploitation	exploitation
3	2	7	–	Country	ceuntry
3	3	7	–	equipment	equipmnnt
3	3	9	–	10	11
3	3	10	—	11	12
4	–	–	2.1	Rapeseed/mustard 33-41.5 (seeds)	33-41.5 (seed)
5	—	–	2.1	Cotton 15-20 (seed)	15-20 seed)
5	2	3	–	atom	atoms
5	2	4	–	atom	atoms
6	–	–	2.2	kg/kernel	kg/kemer
6	-	5	2.2	(kernel)	kernel
6	–	10	2.2	mustard	mustara
8	–	10	2.3	castor	caster
10	2	26	–	supply of the	supply the
11	1	1	–	require sometime	require for some time
12	2	11	–	storage of oil seeds do not require further	storage of oils not required further
12	3	3	–	oilseeds before extraction	oilseeds extraction
13	1	9	–	Ollseeds	Oils seed
13	1	22	–	10-16 mesh	10-16 merh
17	Title of Fig. 3.1	–	–	flow	fow
22	3	8	–	systems	systerns
32	Title des-cription ef Fig. 4 9	–	–	chimney	cnimney
37	Title of Fig. 4.14	—	—	Groundnut Decorticator	Groundnut
37	—	4	4 3	Power	power

ERRATA

Page 1	Para 2	Line 3	Table/Fig. 4	Read 5	In place of 6
38	1	3	–	Anantpur	Anandpur
39	Title Description of Fig 4.16	–	–	Rubber tier assembly	Assembly
10	1	1	—	of equipment is Rs. 3000/- (excluding)	Rs. 3000/- (exculuding)
40	2	6-7	–	undecorticated	undecorficated
41	1	1	–	decortication in	of decortication
41	2	7	–	8.7	87
43	–	10	4.5	weight	weihght
46	Title of Fig. 4.20	–	—	Different	Dirferent
49	Sub-title	–	4.7	Total oil content, % (d.b)	Total oil content % (bd)
54	1	11	–	fotcher	facher
56	1	3	–	treated	treatea
61	3	8	–	Groundnut	Goundnut
62	2	3	–	uptake of flavours	uptake off lavours
64	2	2	–	study	stydy
68	3	9	–	Embonox	Embanox
71	4	4	–	as soon	an soon
71	4	9	–	immediately	immediatly
73	4	9	–	plane	plene
75	1	5	–	traditional	traditionnal
78	–	–	5.3	operation	ooeration
81	2	1	–	recommended	recomonded
87	--	13 under column capacity	5.4	250 kg/batch	250 kg/and 8 KW
87	—	13, under column power requirement	5.4	2 hp and 8 KW	2 hp
90	1	3	—	Rs. 3500/-	Rs. 3500/-
92	1	3	—	addition	additiod
100	—	2	5.20	outlet	outer
102	–	–	5 7	hp	hpr
102	–	–	5.7	req.	eq.
113	1	14	–	oozing of oil out of the	oozing out of the
114	—	–	5.9	Variety	Varisty
114	—	—	5.9	KWh/kg	KWh
118	1	10	—	expelled	expeiled
118	4	4	–	W/v	W/μ
120	—	—	5.13	absorption	e[a]bsorption
125	2	6	—	and at outlet	and outlet
134	4	2	—	structures	struutures
135	1	2	—	mailathion	maiathion
135	1	3	—	seeds inside	seeds the inside
136	1	2	—	tar	tai
136	1	10	—	increased	incraased
137	—	—	137	of saponification	saponifidation