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A REVIEW OF DOMESTIC EXTRACTION TECHNIQUES OF VEGETABLE OIL; AND DEVELOPMENT OF A NEW METHOD USING MODERN SOURCES

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प्रयत्ने वाळूचे कण रगडीता तेलही गळे |
तृषार्ताची तृष्णा मृगजळ पिऊनही वितळे ||
सशाला दिसे विपिन फिरता शृंगही जरी |
परंतु मूर्खाचे हृदय धरवेना क्षणभरी ||
–संत तुकाराम

Fig. 1. The oil can also be extracted from the sand grains, if tried. The water of the mirage will also ruin the thirst. While walking in the forest, even a rabbit can find the horn. But a fool does not restraint the mind for a moment.

Abstract: ***'Ghani' is the old Indian technology of oil extraction. Government of India also provides subsidies to support village industries. Still, this technique has declined abruptly. The reasons may be a lack of knowledge, research (to improve the old method or market competition) etc. Choice of customers is changing, taste is changing. Urban customers are promoting the use of crude oil in spite of refined oil. The properties of oil and oil content get affected by the modern methods of oil extraction. It is necessary to obtain the oil from oil-seeds without changing its protein content. The laborious and tedious traditional methods can be redesigned by using modern equipment. This paper reviews the traditional domestic methods of oil extraction. A new design has been created to extract oil from any oil-seed and method is tested for groundnut, soybean, castor oil. The oil-seeds are pressed and heated to extract oil. The extraction efficiency of this method is around 70 % (Groundnut extraction). The pressure applied is in the range of 200-225 kg=cm2. The temperature is adjustable in the range 90-1800C. Some improvements like steaming, hydro-generation, chemical modifications, filtering, refining, etc. will make the new design of oil extraction, a new way for industrial and laboratory purposes. keyword: extraction, oil, press, manual, Ghani, vegetable, pressing, heating, etc.***

I. INTRODUCTION

At present, oil is extracted from certain seeds and used in daily meals. But, as Saint Tukaram (Sant Tukaram, was a 17th-century poet-saint of the Bhakti movement in Maharashtra, India) said, trying to extract oil from the particles of sand can be possible [Refer fig. 1]. We know that the oil can not be extracted from the sand particles, but the possibility can not be ruled out. This is a challenge toresearchers. Inspired by the said thought; the domestic oil extraction methods have reviewed. Oil seeds are the major source of vegetable oils. Oils provide the calories, vitamins, and essential fatty acids in the human diet in an easily digested form. Oils are used in cooking and industrial applications. The oil-cake remaining after the extraction of oil can be used as animal feeds. [1][2] Few developing countries have surpluses of vegetable oils for export. Malaysia and Indonesia export palm oil, the Philippines exports coconut oil, and Brazil and Argentina export soybean oil. In most developing countries, vegetable oils are in short supply with the rising demand. The need to import increases foreign debt.[1] Palm oil is the principal commodity in the vegetable oil which India is importing; as well as refined oil import has been rising steadily.[3][10][11] Oil seeds grown in rural areas are normally transported to the urban oil mills for processing, but transportation increases the cost of the oil.[1] India's vegetable oil industry has been claiming that the country imports excessive quantities of vegetable oils, hurting the interests of oil seed growers here.[3] Local small-scale oil seed processing offers a simple way for urban and rural populations to extract oil using their own resources. There are a number of domestic or small scale methods to extract vegetable oil. [1][2][10]

These methods are:

- Oil extraction using water
- Manual methods using kneading
- Manual presses
- Ghanis
- Screw expellers

Villegas et al. (1968) had shown that commercial sesame meal obtained by means of continuous screw-press processing at high pressure and temperature had a 13% reduction in nitrogen solubility (in 0.02 N sodium hydroxide) and 5% lower protein digestibility which they attributed to the dry heat effect on the seed during processing. They also found that lysine availability in all cases was less than 50% of the literature value for total composition (2.22% of the protein content,N.R.C. 1994), and that methionine availability was increased (15 to 22%) by heat treatment. They concluded that the commercial process for the extraction of sesame oil were responsible for the 40% reduction in lysine availability. [4] It is a need of the time to develop a homemade method to extract oil from oilseeds. This paper explains about the various oil extraction techniques used traditionally and a new designed method based on the modern available sources. If this method is

implemented in every house to extract oil, oil will be available at lower rates for urban as well as rural India; overall imports can be reduced. The suitability of each method depends on individual requirements, availability of space and power.

II. SUITABILITY OF METHODS FOR DEVELOPING COUNTRIES

India is a developing country and leading business is agriculture, methods of oil extraction can be used appropriately. The local conditions and environment, availability of seeds, seed types, etc. be the major factors to get success. These processes are simple and do not require expensive equipment and can be operated at household level. Example-Oil extraction using water.[1] The expeller and Ghani methods require a substantial capital investment; these methods are best suited to run through the Co-operative Housing Society in urban areas. By contracting the farmers to provide oil-seed; the members of co-operative housing society will handle the financial transaction carefully. The output products are oil and oil-cake, hence no wastage. Retailing of oil cake reduces the production cost.[1][3][2] The farmers if implemented the expeller method get benefited by having local, an assured outlet for his seeds, oil cake to feed his animals and get the cooking oil for home consumption.[1]

III. STEPS IN OIL EXTRACTION PROCESS

Fig.2 shows the steps to extract oil from the oil-seeds.[1]

Cleaning: The oil-seed is cleaned to remove trash, dirt, sand and metal pieces. The quantity of oil-seed is then decided based on oil required.

Decortication: The process of removing the shell or seed coat is known as decortication. So that the oil content of the raw material entering the extraction machinery is raised. It ensures a higher protein content in the oil-cake.

Size reduction: To reduce the size of the seed, it is crushed.

Rolling: Rolling is followed after the third step to produce flakes.

Conditioning: It is followed after rolling. During conditioning, the seed is heated and often treated with steam. This step is required, in order to rupture the oil bearing cells and to maximize the oil extraction efficiency.

Extraction: Oil is extracted from the conditioned seed particles in screw expeller. The flak seed or oil cake, then

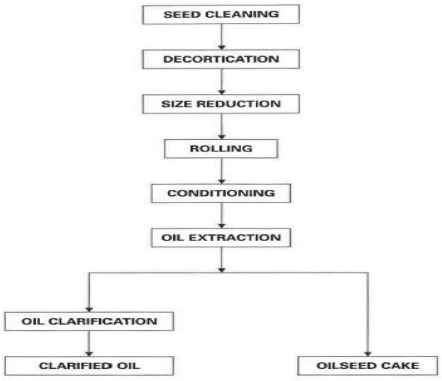

Fig. 2. Steps in oil seed extraction

treated with solvent; in which oil is soluble. The process is known as ”solvent extraction”. The solvent is removed by heat and vacuum to obtain the crude oil. (Expellers leaves a residual oil content in the oil-cake of about 5-8%. Solvent extraction removes nearly all the oil, leaving only about 0.5% oil in the residue.[1][2])

Oil Clarification: The crude oil from the expeller is passed through the screens. It is allowed to settle in tanks before it is filtered through a filter press.

Recycle: The seed residue from the settling tanks is known a ’foot’. Residues from the screens, the filter press, and the ’foot’, are re-processed in the expeller by mixing them with the fresh oil seed feed stock or oil-cake. Oil-cake is frequently passed through the expeller to remove more oil.[1]

Refining: Three main steps of refining the Crude oil are a)Neutralization (Removing Fatty acids),

Oil is mixed with a solution of caustic soda, to neutralize the fatty acids. The caustic soda solution reacts with the fatty acids to produce soap; which can be washed from the oil with water. The soap solution, known as a soap-stock. It can be used for soap manufacturing [1].

b)Bleaching (removing color) The oil is then bleached by adding a powdered clay known as ’Fuller’s earth’. This operation removes colored pigments and produces a light-colored oil.[1]

c)Deodorizing (removing off flavor),

Deodorization is carried out by passing high pressure steam through the oil under vacuum. The high pressure steam removes the taints and odors present in the oil at the beginning of the refining process, and those produced during the neutralizing and bleaching stages. A bland-tasting oil is eventually obtained.

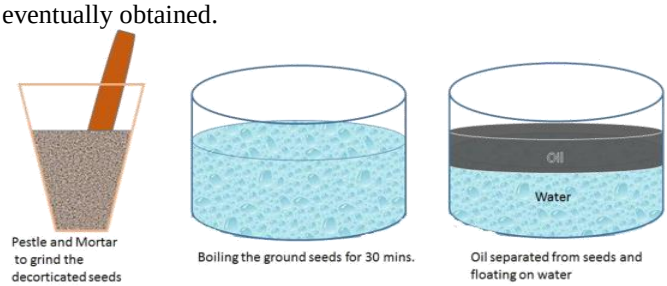

Fig. 3. Hot water flotation

Oil-cake: Oil-cake is sold to the animal feed compounder who blends it with other ingredients to make rations for farm animals.[1]

IV. DOMESTIC OIL EXTRACTION METHODS

Small- scale techniques can be utilized to extract oil from oil seeds. This enables farmers and urban people to process oil seeds locally. The small-scale oil seed extraction up to 100 kg seed/hector includes small powered expeller, manual-or animal-powered mechanical presses, and simple procedure using water to separate oil from oil seeds. In most of the developing countries, every year the demand of edible oil (both for domestic and industrial uses) rises. Therefore, continuous study of old methods and inventing new techniques of oil extraction will provide best quality oil for domestic and industrial use, by reducing complications of

traditional processes. The various oil-seed processing methods are given below. The first three methods are suitable to use in households. The methods Ghani and expeller is mostly suited for small scale factories. But these methods can be installed by housing cooperative societies in the urban areas.

- Domestic method (Hot water flotation)
- Native or Local method (manual methods using kneading)
- Hand-operated presses;
- Ghanis; and
- Expellers.

V. DOMESTIC METHOD (HOT WATER FLOTATION METHOD)

The hot water flotation (HWF) method is in use for the rural areas of many developing countries to extract the oil. Decorticated oil seed core is heated and ground by pounding on a pestle and mortar. The ground seed is then suspended in boiling water and boiled for at least 30 mins. Separated oil floats through the surface as shown in fig.3. Some water is sometimes added after boiling to replace that lost water by evaporation and to allow the oil to float to the surface. The oil is carefully scooped from the surface of the water using a shallow dish. The scooped oil, then heated to remove residual moisture.[1][3][11] The simplicity of this process is the advantage over small-scale oil-seed processing methods. The equipment required are pestle and mortar, boiling pans, etc., which are easily available. The extracted oil quantity is low and the process is time and energy consuming. The method may be applied to most oil seeds.

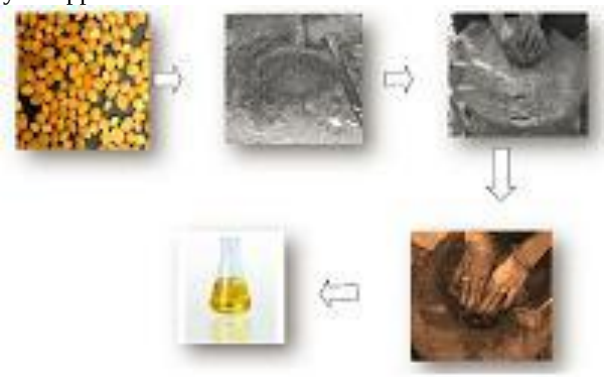

Fig. 4. Oil extraction of Apricot. (Source:Small Scale Vegetable Oil Extrac-tion[1])

VI. NATIVE OR LOCAL METHOD (MANUAL METHODS USING KNEADING OR SQUEEZING)

In common with the water flotation process, simple domestic utensils are needed to extract oil by kneading. This method is used to process groundnuts traditionally in West African villages. Water is added to groundnut paste and the mixture is stirred and kneaded by hand until the oil separates. The water plays a vital, but obscure role in the extraction process. [1]

Example: The process is used to extract oil from Apricot. The Apricot fruit is collected and fleshy portions of the seed are separated by pressing with hand. The hard seed is softened by immersing in water for 10 -20 mins. The hard shell is separated by pressing on the flat stone. The kernel gets separated and crushed to powder using pestle and mortar. The Crushed Apricot is ground to fine powder on the flat stone or slightly curved stone as shown in fig. 4. The slightly curved stone has a cup shaped groove at the end is heated. The temperature can be adjusted by keeping the stone away from the fire or by lowering fire. The ground paste is dough thoroughly with bare hand on heated stones. During the process, Handful of water is sprinkled on the dough which enables extraction of oil.[5]

VII. HAND-OPERATED PRESSES

The various manual presses traditionally used are:
The wedge press
The plank press
The cage press
The curb press a. The bridge press b. The scissor press
c. The hydraulic press d. The ram press
The above methods are named according to the pressing method used.

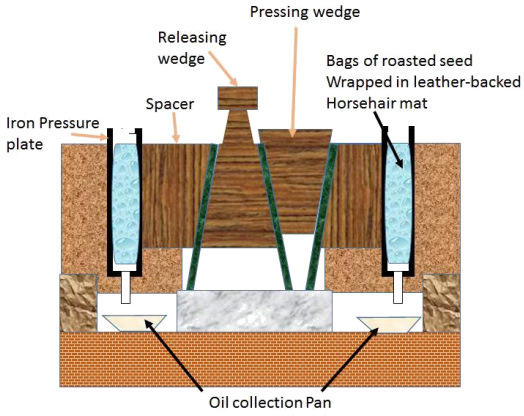

Fig. 5. The wedge method

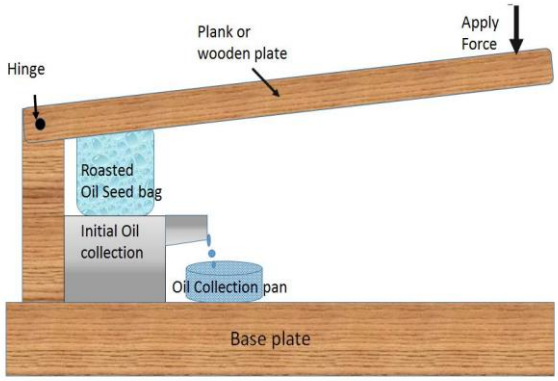

Fig. 6. The plank method

A. The wedge method

The wedge press, operated manually or by using either wind or water power. It was widely used to press oil seeds during the late 18th and early 19th centuries in the West and in the Far East. The typical operating principle of a wedge press used during this period is shown in fig. 5. The wedges should be made of a very hard wood. The wedges are driven in with a wooden mallet.[1][5][6]

B. The plank Press
The plank press is the simple pressing device to extract oil. Refer fig. 6 and 7 for principle of working. It uses two long pieces of wood which are hinged at one end. The prepared seed (in a suitable woven container) is placed between the planks and squeezed by the application of pressure on the hinged ends. The plank press used in Nepal for the extraction of rapeseed oil.[1][5] [6]

C. Cage press
Cage presses are sometimes called screw presses. There are a number of cage press designs. The four types are shown in fig. 8-12.[1]
These are:

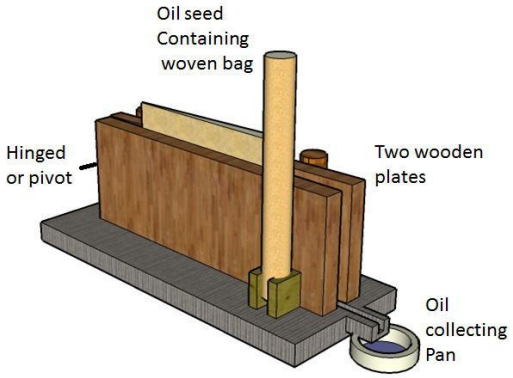

Fig. 7. Alternate plank method

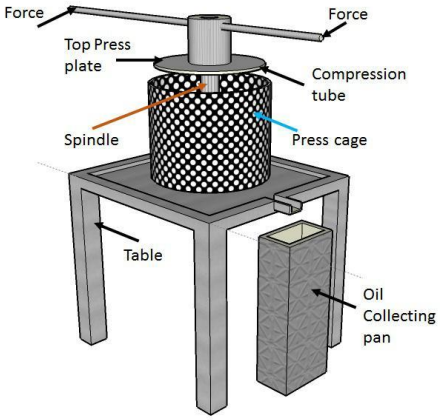

Fig. 8. Curb Press, TCC design

The curb press: The press working principle is shown in fig. 8. It was designed by the Technology Consultancy Centre (TCC) at Kumasi in Ghana. It has been widely used in Nigeria for extracting palm oil.[1]

The Bridge press: Fig. 9 shows the working principle of the bridge press. In this press, the pressure plate is mounted on the base of a screwed rod. The screwed rod runs in a nut set in the 'bridge' of the frame that surrounds the cage. The screwed rod is turned by a single cross-head bar.[1]

The scissor press: This press (see fig. 10 for working principle) was designed by the Institute of Production Innova-tion (IPI) in Dares Salaam, Tanzania. It is used for processing sunflower seed by hand. This kind of press can exert a force of 80 tonnes.[1]

The hydraulic press: A simple form of this type of press is shown in fig. 11. The press was developed for processing Shea nuts. It uses the principle of a 30 tonne lorry jack which exerted a maximum pressure of 125 kg=cm2 on the seed. The cage capacity is 8 liters.[1]

The hydraulic jack is mounted on the pressing cage. This design is not recommended as there is the risk of leaking hydraulic fluid which could get mixed with the oil and cake.[1]

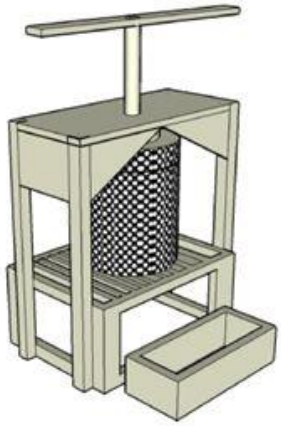

Fig. 9. The bridge press working principle, NRI design

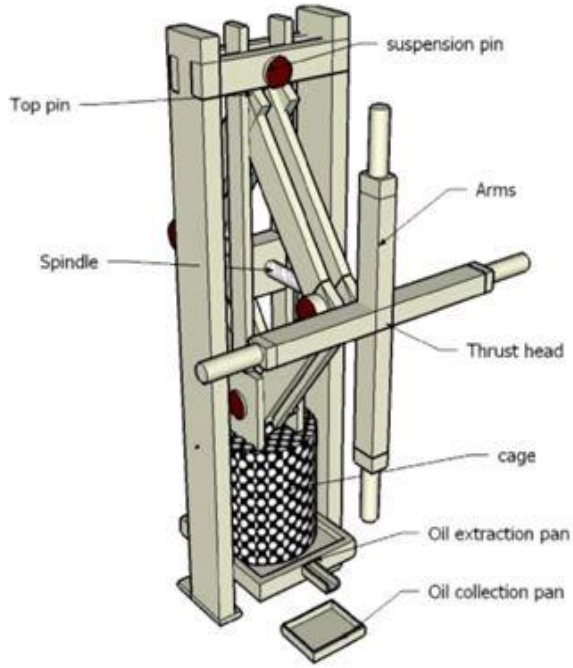

Fig. 10. The scissor press:IPI

The ram press: The ram press was designed in 1985 by Carl Bienlenberg, an engineer working with Appropriate Technology International (ATI). Refer fig. 12 for working principle. The ram press was developed in Tanzania specially for processing a thin shelled a high oil-content variety of sunflower seed. Presently, the technique is used to extract the oil from copra, groundnut and sesame oilseeds.[1]

VIII. A NEW DESIGN

The fig. 13 shows the new design. The major components are seed cage, press plate, screw, top cap, bottom cap, wooden side structure, heating element. The rise in temperature =50-90 0C. The maximum pressure applied = 45 85kg=cm2 The method may be applied to most oil seeds. The new method has the potential to get 50 ml oil in 30 minutes from 150 grams of peanut seeds. Decortication of seeds like soybean seed can be done by immersing it in boiling water. The water gets added and seeds become soft (like groundnut) and then pressed and the oil can be extracted.

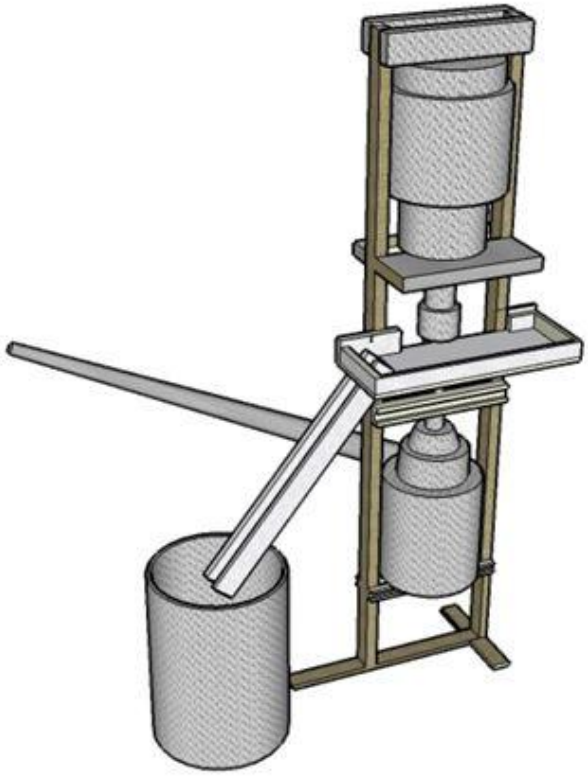

Fig. 11. Hydraulic press: KIT design

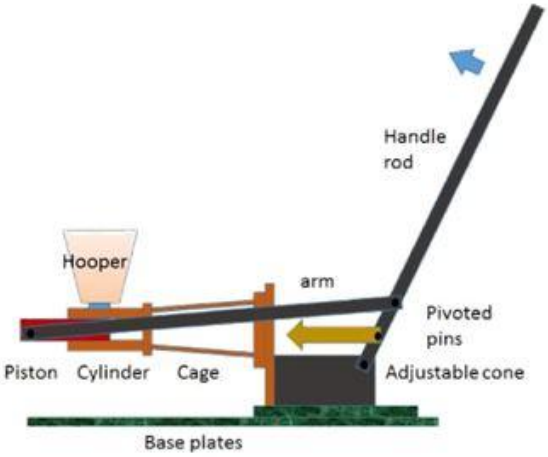

Fig. 12. The ram press

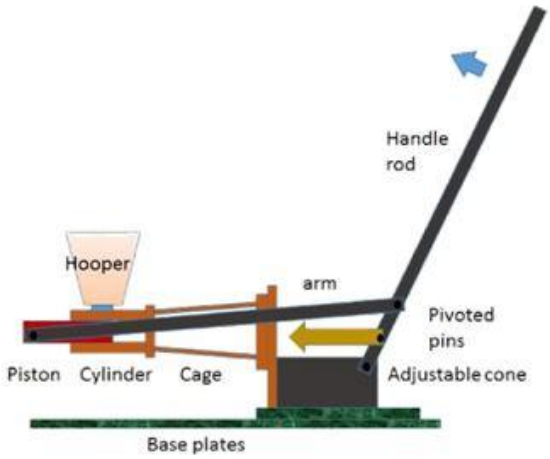

Fig. 12. The ram press

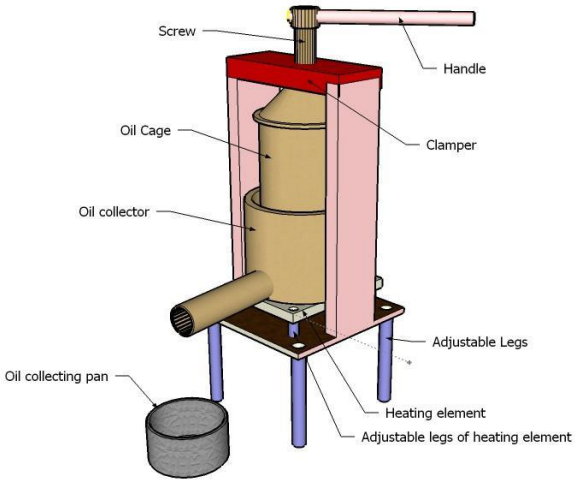

Fig. 13. New design

Fig. 14. The New design

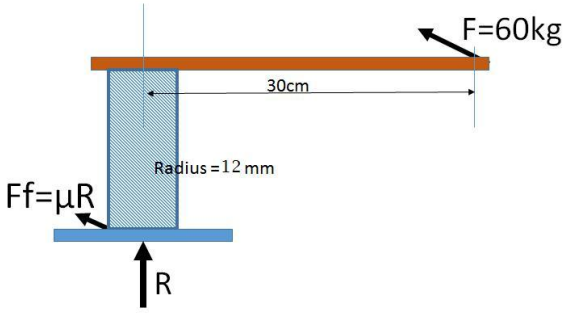

Fig. 15. Pressure calculation

Fig. 14 shows the photograph of the new design made from available equipment. The screw legs can be adjusted to tilt the complete assembly. A piece of pipe and c-spanner used for rotating the handle and holding the cage while applying the pressure on the seeds.

IX. PRESSURE ON THE SEEDS

Refer fig. 15,

A man can apply force by one hand up to 45kg (450N). The total torque applied on the screw calculated as, T= 450 x 30 = 13500 N.cm

The same torque transmitted to the pressure plate. If the coefficient of friction is 0.3 between screw and pressure plate. T= x R x r ,

where = coefficient of friction.

R= the reaction and r= radius of the screw rod T=13500 N.cm = x R x r 13500 = 0.3 x 0.6 x R

R = 75000 N or 7500 kg

Area of pressure plate = 4 x (6)2 = 28:26cm2

Pressure on oil seeds = 265 kg=cm2

The maximum pressure ranges from 225 to 265 kg=cm2

X. EXTRACTION EFFICIENCY

Extraction efficiency (EE), an important quantity in oil-seed processing. It is the percentage of oil extracted in relation to the amount of oil present in the seed.[1] Oil-seed is mixtures of oil, meal and water. Processing removes most of the oil and the remaining portion is called oil-cake. Oil-cake contains the residual oil, the meal and water. Since the meal is mainly composed of protein, carbohydrate and fiber, oil-cakes in general are excellent materials for animal feeds. The oil contents compared with a dry weight or 'moisture free basis' (MFB).[1]

The groundnuts up to 150 gms (% oil content 45-55) are processed to extract 25 gms of the oil, using the new designed method.

The extraction efficiency (EE) is:

$$EE = \frac{25\ 150}{50} = 75\ \%$$

The extraction efficiency is dependent on the oil content of the seed. Low oil contained seeds give less extraction efficiency. Extraction efficiency in large -scale processing is in general 90%. Whereas in small- scale processing, extraction efficiency is in the range 60-65%.[1] The new design showing a better result. The extraction efficiency is 75 %. Efficiency of hot water floating, the plank press, ram press, Ghani process was 41%, 70%, variable, 26.47% respectively. [7]

Caldwell (1958) reported that overheating (more than 115.6C) sesame meal may result in a reaction of the amino acids lysine, arginine, and tryptophan with free carbohydrates, which produce compounds that are not readily absorbed in the digestive tract.[4].

So the processing temperature should be selected properly. The arrangement to adjust the temperature is provided with the new design. The variation in temperature is within the range 90-180^{0}C Most of the oil has thermal stability up to 200^{0}C. [8].

XI. PROCEDURE

Refer fig. 16,

Hold the cage in the hand and place the bottom cap and rotate to fix it.

Pour the seeds (The groundnuts can be poured directly or by roasting it.) The hard seeds like soybean are softened by immersing in cold water or hot water for 10-30 mins. depending on hardness to break the hard shell. The hard shell is separated, dry it for some time and then pour it in the cage. The pressure plates are kept in between.

Place the top cap and rotate the handle to apply pressure on the seeds.

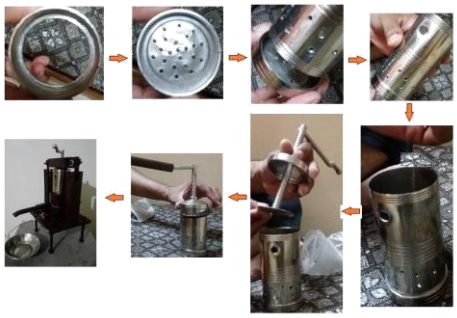

Fig. 16. Procedure

Place the cage assembly in the oil collecting cup and using bracket, fix its position.

Apply the pressure on the oil-seeds by rotating the handle. To rotate the handle, use the pipe and C-spanner. Adjust the temperature as per the oil-seeds extraction temperature. Switch on the supply of heating element.

After 10 to 20 mins. the oil extracted and drops out from the pipe. Collect it in a dish. The dish is heated to separate the moisture if required.

After every 15-20 mins. rotate the handle to apply pressure on seeds. This is required because as oil extracts from the oil-seeds, the pressure gets released.

The oil cake can be separated from the cage by opening top and bottom cap. The oil cake is recycled by placing it above the fresh seeds in the cage.

The cycle is repeated for next extraction.

XII. ADVANTAGES AND DISADVANTAGES

The "modern" word is representing the existing process. The "new method" is for developed method and "The traditional method" is the old method. Advantages:

- Less labor work.
- Preferred by consumers as compared to modern

methods as the method is very similar to traditional methods.
- Effective extraction of oil.
- Oil cake can be used as animal food or other food ingredient.
- Produce sufficient quantity (for experimental purpose and household requirement.)
- As it is manually operated, can be used in the remote areas where electricity is not available. (The heating element can be battery operated or arranged from natural sources.)
- Less precautions and safe in operation.
- During the process, moisture contents get separated; as heating temperature is around 60-900C.
- The temperature is adjustable and selected based on the seeds to be processed.

Disadvantages:
- When seeds are decorticated by using water, the oil extracted has a distinct smell.
- The process is still time consuming compared to modern methods
- No automatic feeding of seeds.
- Less cage capacity, around 150 grams of seeds.
- Less oil quantity gets extracted, limits the use for commercial purpose.

XIII. CONCLUSION

The oil extracted by using traditional methods is preferred by the consumers. The most of the refineries are using the modern methods. The availability of oil extraction by traditional method is less. The traditional method has certain limitations like low rate of extraction, laborious and tedious work. The process is required which resembles the traditional method and uses the modern techniques. The new designed method of extracting oil is based on the traditional oil extraction concept using modern equipment. The equipment is readily available, so reducing manufacturing cost (please refer cost table 1). The extraction efficiency is 75% for groundnut processing. The extraction efficiency is dependent on the oil content. The small-scale processing, extraction efficiency is around 60-65%. Heating the pressed oil seeds up to temperature 60-900C gives the better result. The moisture content is less in the extracted oil. The method can be modified by other processes like decortication, steaming, chemical modification, etc.; will make it suitable for industrial and laboratory purposes. It can be suitably used for domestic purpose.

XIV. FUTURE WORK

After some improvement, the new method is suitable for domestic, laboratory purposes and small industrial applications.
The modifications required are
- Steaming of seeds(to soften the hard seeds).
- Hydro-generation to saturate the oil extracted(Process to increase the oxidation stability of oil).
- Chemical modifications set up(Process to increase the oxidation stability of oil).
- Filtering of extracting oil.
- Refining of extracting oil (if required).
- Decortication methods of various seeds.

XIV. COST TABLE

The total manufacturing cost of new designed method is as given in table 1.

TABLE I: MANUFACTURING COST OF ONE UNIT

S. N.	Equipment	Cost
1	Press cage with caps, screw and handle	Rs. 300/-
2	Wooden frame	Rs. 150/-
3	Standard four bolts M 10 with nut	Rs.100/-
4	Standard Plates with nut and bolt	Rs. 80/-
5	Heating element and thermostat	Rs. 200/-
6	Cord	Rs. 80/-
7	Oil cup	Rs. 150/-
8.	Dish	Rs. 25/-
	Total	Rs. 1085/-

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