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PRODUCTION OF OIL FROM SESAME (BENNISEED) THROUGH SOHLEX EXTRACTION AND ITS BENEFIT

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ABSTRACT

The paper examined the processes involved in production of oil from sesame seed through sohlex extraction, N-hexane (Cyclohexane) was used as a solvent. Different variables of sesame seeds were investigated in term of particle sizes, ratio of solvent to seeds mass and quantity of oils produced from the process. The nutritional value of the oils equally discussed, such as Calcium, Phosphorous, Magnesium, and Potassium in large amounts and it also contain vitamins such as Niacin, Thiamin, Riboflavin and vitamin B-6, oil content and Fatty acid composition in Sesame seeds were examined and Modification of fatty acid composition in sesame oils also discussed. In the course of production, the process faced with some challenges like, lack of improved cultivars, poor seed supply system and poor management practices. Sesame oil has some health benefits such as it provide proteins, vitamins and amino acids. Due to certain challenges identified from production processes some recommendations were made and with its numerous benefits the researchers deem it fit to pass the information to our science students graduate to engage in the production of sesame seeds to reduce unemployment rate in the country

Keywords: *Extraction method, Nutrition, Sesame seed, Sesame oil, Sohlex, Solvent*

Introduction

Sesame is also known as Gingelly and Sesame in English, Tila and Snehphala in Ayurveda, Til and Kunjad in Unani. Sesame is typically an

erect branch annual (occasionally perennial) 0.5-2 m in height with a well-developed root system. It is multi -flowered and its fruit is a capsule containing a number of small oleaginous (oily) seeds. Sesame seeds are very small in size and are 4mm long 2mm wide and 1mm thick. They are pearl shaped, ovate, small, slightly flattened and somewhat thinner at the hilum. The varieties and strains differ considerably in size, form, growth, flower colour, seed size, colour and composition

Sesame (Sesamum indicum) is cultivated in several countries such as India, Sudan, China and Burma which are considered as the major producers (60% of its total world production) Sesame seeds have been used as health food for disease prevention in Asian countries for several thousand years. In some areas in Nigeria mostly in the northern part of the country, benniseed is sustainability used as a snack. The literature reports indicate many health benefits associated with the consumption of sesame seeds; for example, they significantly increase plasma γ-tocopherol and enhance vitamin E activity, which are believed to prevent human aging-related diseases such as cancer and heart disease. Studies have also shown that including sesame in the diet can improve anti-oxidant capacity Sesame seed has higher oil content (around 50%) than most of the known oilseeds. Sesame oil is generally regarded as high-priced and high-quality oil. It is one of the most stable edible oil despite its high degree of un- saturation. Sesame oil is rich in monounsaturated and polyunsaturated fatty acids.

The most abundant fatty acids in sesame oil were oleic, linoleic, palmitic, and stearic acids, which together comprised about 96% of the total fatty acids.

Aims of the Research

The main aim of the research is to discuss the process involved in the extraction of oil from sesame seeds and its benefit to human

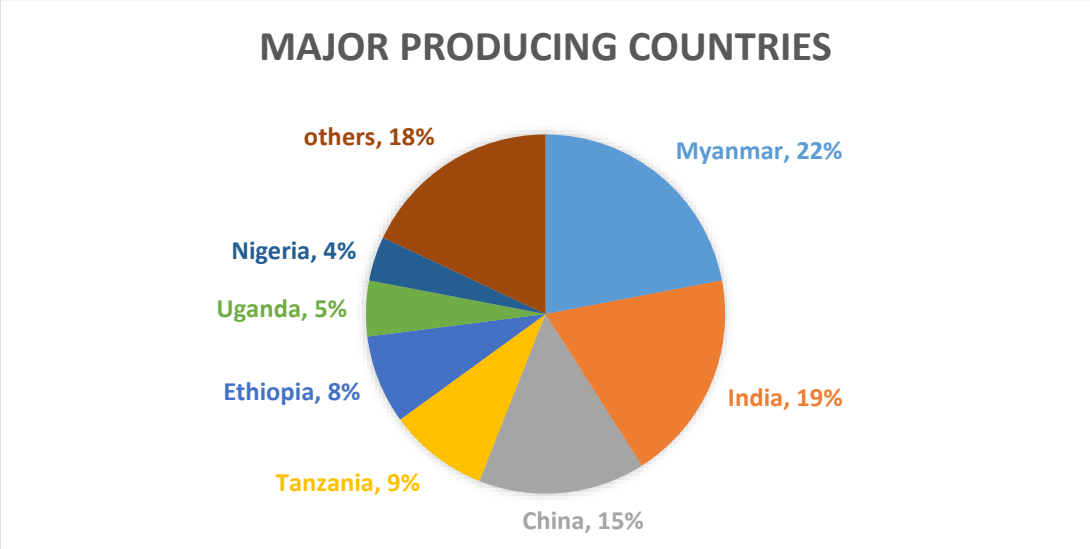
The objectives are

1. To discuss all the processes involved in extraction of oils from sesame seeds
2. To explain the benefit of sesame oils to human
3. To examine the composition and other contents of sesame oil

Review of Related Literature

Sesame (Sesamumindicum L.) is an ancient oil yielding crop and popularly known as "Queen of Oilseeds". Sesame belongs to Tubiflorae order and Pedaliaceae family. The genus Sesamum has 37 species, of which Sesamum indicum L. is the dominant cultivated species. Distribution of most of the species occurs in three regions viz., Africa, India and the Far East. It is one of the ancient oil seed crop originated in Africa. In production of Sesame seeds Myanmar ranks first in producing 8, 61,573 T that of India ranks second in production having 7, 69,000 T. In terms of area India ranks first harvesting about 17, 80,000 Ha as that of Myanmar having 15, 84,000 Ha. India enjoys the paramount position for export of white seeded type seeds which are in great demand. India is one of the largest exporters of Sesame seeds exporting between 3 to 4 MT of seeds annually.

India is the largest producer of Sesame covering 42 % of world's Sesame area and 27 per cent of the production and nearly 7.4 % of the total area under oilseeds in India. Sesame ranks third among the oilseed crops in production. The top ten Sesame growing countries by production of Sesame seeds are Myanmar, India, China, Ethiopia, Nigeria, Uganda, United Republic of Tanzania, Niger, Burkina Faso and Somalia. (FAOSTAT, 2011).



The composition of sesame possesses lipid contents 48gms, carbohydrates 25.7gms, proteins 17gms, fiber 14gms and ash 6gms approximately with respect to 100gm of seeds. Sesame seeds are rich in minerals such as Calcium, Phosphorous, Magnesium, and Potassium in large amounts and

also it is having vitamins such as Niacin, Thiamin, Riboflavin and vitamin B-6

Table 1: Nutritional value of sesame seeds and oils

mount Per 100 grams			
Calories 573			
Value*			%Daily
Total Fat 50g			76%
Saturated fat 7g			35%
Polyunsaturated fat 22g			
Monounsaturated fat 19g			
Cholesterol 0 mg			0%
Sodium 11 mg			0%
Potassium 468 mg			13%
Total Carbohydrate 23 g			7%
Dietary fiber 12g			48%
Sugar 0.3 g			
Protein 18 g			36%
Vitamin A	0%	Vitamin C	0%
Calcium	97%	Iron	81%
Vitamin D	0%	Vitamin B-6	40%
Cobalamin	0%		Magnesium
87%			

(USDA Nutrient Database, 2015).

*Per cent Daily Values are based on a 2,000 calorie diet. Your daily values maybe higher or lower depending on your calorie needs.

Problem Associated to Sesame production.

The productivity of Sesame in Nigeria is very low of about 432 Kg/ha against the yield potential of 2000 Kg/ha. Despite the potential for increasing the production and productivity of Sesame there are a number of challenges inhibiting Sesame production and productivity.

Among the many production constraints are,

lack of improved cultivars and poor seed supply system which is very much restricted to poor soil and several other constraints such as low and unreliable yield, shattering, high production cost and lower return to the farmers.

It is also having nutritional disorders such as Manganese deficiency in which Leaves develop interveinal chlorosis, chlorotic tissue, later develop light brown or husk coloured necrotic lesions and also having Zinc deficiency in which middle leaves develop chlorosis in the interveinal areas and necrosis along the apical leaf margins.

There is increasing evidence that the uses of poor management practices (especially the practice of low seed rate) as well as traditional cultivars are the main yield limiting factors in Sesame farms of sandy

The yield potential of Sesame is very low when compared with major oil seed crops due to early senescence and extreme susceptibility to biotic and abiotic stress factors including photosensitivity.

Methodology

Materials and Equipment

Sesame seeds, n-hexane, sieves, milling machine, sohlet extractor (cyclohexane solution), rotary evaporator, distillation apparatus container (keg) and laboratory atmospheric

Extraction stages

Benniseed (sesame seed)

⇓

Sieving

⇓

Crushing or milling

⇓

Solvent extraction with Cyclo Hexane Solution

⇓

Distillation (Rotary evaporator)

⇓

Extraction of oil

Samples Preparation

Freshly season sesame seeds were purchased from the local market at Gwagwalada area of FCT-Abuja. Particle impurities such as dust, sands, stones, spoiled seeds, small weed seeds and other extra materials were separated by mechanical sieves then washed with water for further cleaning and left to dry at room temperature for 48 hours.

Extraction Process Variables

In this research, various operating parameters that the researchers believe play an important roles in extraction were investigated, that includes particle size, ratio of solvent to sesame seeds mass, sohlet extraction and packaging. Conditions of each parameter are presented as follows:

Particles Size

Five samples were taken with different average particle size (2, 1.5, 1, 0.8, 0.5 mm) to investigate the optimum sizes that yields higher oil extraction. Good quality selected seed milled into powder

Powdered seed to Solvent Mass Ratio

5kg of powdered sesame seed mass to 3.6 litres of solvent (cyclohexane solution). Solution was kept for 24 hours before being filtered to remove any depositions that may occur

Sohlet extraction of sesame seeds

The solution of powdered seed and cyclohexane passes through the sohlet extractor to extract oil from the solution; the extracted oil was then separated from the hexane using distillation (Rotary evaporator). The extracted oil passed through the rotary evaporator to free the extracted oil from the solvent i.e. solvent (Cyclohexane Solution). The extracted oil further kept inside the fume cupboard to remove any residual solvent from the extracted oil and finally stored in a clean keg for use.

Result

Solvent extraction (Sohlex), provide higher yields—98% - 99% is nowadays the dominant technique applied in most extraction processes.

Solvent extraction becomes the commonly used commercial technique to recover oil from oilseeds, presently n-hexane is the preferred solvent throughout the world due to its extraction efficiency and ease of availability In comparison, solvent extraction with hexane (the primary solvent used worldwide) will re-move all but about 0.5% of residual oil, useless horsepower and require less maintenance. Hence, it is relatively efficient and reliable. In this study, optimization of n-hexane extraction is defined by studying the parameters which affect the process. Investigations examined different ratios, from 1:1 up to 8:1. Results showed maximum extraction yield of 37% oil when applying a ratio of 6:1. Further increase of solvent amount had no impact of extracting further oil percentage as presented.

It is clear that the more time seeds are given in contact with the solvent the higher the extraction yields percentage, this is true for 24 hours and afterwards no more extraction had been noticed the solvent extraction is the key point-operation. Extraction takes place due to the affinity of solvent towards oil. The affinity is mainly chemically based. Various researchers studied the impact of different solvents on sesame oil extraction, used n-hexane, cyclohexane, and benzene, mixture of n-hexane/chloroform (2:1, v/v), chloroform, acetic ether, butanol and acetone. On the other hand some researchers used hexane and used compressed propane and supercritical carbon dioxide. Majority of researchers found that n-hexane yields higher extraction percentages making it the optimum solvent. Solvent extraction, providing higher yields—98% - 99% is nowadays the dominant technique applied in most extraction processes. Solvent extraction becomes the commonly used commercial technique to recover oil from oil seeds, presently n-hexane is the preferred solvent throughout the world due to its extraction efficiency and ease of availability. In comparison, solvent extraction with hexane (the primary solvent used worldwide) will re-move all but about 0.5% of residual oil

Local method:

Benniseed oil is extracted locally by first roasting at about 180oC TO 210oC, this process is followed by Milling and pressing out the oil by the application of hot water (70oC to 85oC).

The mechanical method was an early means of separation which was physical pressure to "squeeze the oil out". The most energy efficient, practical embodiment of that method is the modern screw press. More than half of the oil is easily removed in this way, but perhaps 7% or 8% residual oil is left in the cake solid. The process uses considerable horsepower and requires more maintenance, in addition it also requires more machines setups for higher capacity. In a nutshell, such techniques are no longer prevailing currently due to the higher cake oil content.

The benefit of sesame oil to man

The use of this oil is of significant important. The health benefits of sesame seeds oils include the followings:

Sesame Seed Oil for Oral Health – One of the most prominent benefits of sesame seeds and sesame oil revolves around removing dental plaque and boosting oral health. By engaging in an activity known as oil pulling, which involves swishing oil around in your mouth, you can boost oral health and even whiten your teeth. One study showcases the oil pulling benefits on the oral level, where oil pulling with sesame oil was shown to reduce the amount of streptococcus mutants in both teeth plaque and mouth saliva and boost overall health.

Helps Prevent Diabetes – Thanks to magnesium and other nutrients, sesame seeds and especially sesame oil has been shown to combat diabetes. One study published in 2011 in the American Journal of Clinical Nutrition, found that sesame oil "improved the effectiveness of the oral antidiabetic drug glibenclamide in type 2 diabetic patients". As the sole edible oil has an additive effect in further lowering BP and plasma glucose in hypertensive diabetics".

Reduces Blood Pressure. Sesame oil has been shown to lower blood pressure in hypertensive diabetics. Additionally, magnesium has been shown to help lower blood pressure – and sesame seeds are loaded with magnesium.

Promotes Heart Health – Further adding to the health benefits of sesame seeds, sesame seed oil can boost heart health by preventing atherosclerotic lesions. An antioxidant and anti-inflammatory compound known as sesamol, which also harnesses anti-atherogenic properties, is thought to be

one reason for the beneficial effects. According to Green MedInfo, sesamol has been shown to "possess over two dozen beneficial pharmacologically active properties, many of which may contribute to improving cardiovascular health".

Protects against DNA Damage from Radiation – Sesamol, a compound found in sesame seeds and sesame oil, to protect against DNA damaged caused by radiation. Also extend life in mice treated with radiation, partly by preventing damage to the intestines and the spleen.

Prevents Cancer – Not only do sesame seeds contain an anti-cancer compound called phytate, but the magnesium in sesame seeds also harnesses anti-cancer properties. One study published in the American Journal of Clinical Nutrition found that the risk of colorectal tumors decreased by 13% and the risk of colorectal cancer decreased by 12% for every 100 mg of magnesium taken in.

Boosts Bone Health – In addition to promoting healthy skin, zinc has also been shown to boost bone mineral density and bone health as a whole. One study, published in the American Journal of Clinical Nutrition, found a correlation between zinc deficiency and osteoporosis in the hip and spine area. What's more, sesame seeds are a great source of calcium – a known trace mineral that is essential for bone health and preventing related conditions.

Boosting Digestive Health and Relieving Constipation – Sesame seeds are rich in fiber, which is known to pave way f or a healthy digestive system and a healthy colon.

Provides Relief from Rheumatoid Arthritis – A mineral that is important for anti-inflammatory and antioxidant enzyme systems, copper is known for reducing pain and swelling associated with arthritis. Additionally, this mineral helps provide strength to blood vessels, bones and joints.

Promotes Respiratory Health and Prevents Asthma – Thanks to the magnesium, sesame seeds are able to prevent asthma and other respiratory disorders by preventing airway spasms

Apart of oil from sesame seeds, other Benefits of Sesame Seed to Man includes:

A. Conversion of Waste - to – wealth: It has been observed that benniseed has been properly utilized for the benefit of the masses.

In the process of production it will provide job for people to work in the factory. The chaff can be used as supplement in animal feeds.

B. Source of oil: This seed is just been consumed locally as snacks and mostly by children. For better usage this seed has lot oil for cooking and other use. Oil will bring improvement in the health levels of the population. This project will provide easy asses to facilities for the attainment of this lofty objective.
C. Provision of employment: On successful completion, the project facilities can be scaled up and assembled as a package for medium and Small Scale Entrepreneurs. When sited at different locations in the country, such production facilities have the capacity to employ a large number of people. When some are working on process and selling of the oil, more seeds will be produced. Since the products will be disposables and there will always be ready market for the product.
D. Acquisition of Technical knowledge: Though theoretical knowledge of the preparation of oil from benniseed may not be new (the local means), this project will provide a foundation for the practical experience and ability to produce high quality grade of the material from completely simple inputs

Oil content and Fatty acid composition in Sesame seeds:

Sesame seeds are highly priced oilseed in the ancient world because of its resistance to drought, the ease to extract oil from seeds and the high stability of oil. Sesame is one of the world's most important oil seed crops due to its relative superior oil quantity, having oil content generally over 50 per cent. Vegetable oils and fats constitute an important component of human diet, ranking third after cereals and animal products. Oil forms the basic cooking medium for majority of dishes, especially of Indian cuisine and enhances the taste of these preparations, seeds also have long been considered a very popular health food in Asian countries. The per capita recommended oils and fats is 30 g per day but their availability in India is despairingly below this level. Sesame oil consumption meet demand of adequate amount of essential fatty acids that is important for normal

growth and development. This underlines the need for a concerted effort to enhance the oil production. Sesame seed oil has excellent stability due to natural antioxidants such as sesamolin, sesamin and sesamol. Sesame has relatively superior oil quantity as well as quality in comparison to many major oil crops. The oil content ranges from 34.4 % to 59.8 % but is mostly about 50 % of seed weight.

Both genetic and environmental factors influence the oil content in Sesame, late maturing cultivars are reported to have high oil contents than early ones. Variations also occurs between capsules at different position on the same plant, such that the seeds from the basal capsules on the main stem contains more oil than those located towards the apex and on side branches black seeded cultivars often have lower oil content than brown and white ones, indicating a possible linkage between oil content and seed coat colour. Black seed coats are usually thicker than lighter coloured ones. Sesame seed has high amount of methionine. Seed is an important source of protein also rich in thiamine and niacin is used for industrial purposes. Sesame oil is a pale yellow odourless oily liquid with a bland taste and it is a good source of edible gourmet oil.

The Sesame genus has limited variability in the seed fatty acid proportions. The seed fatty acid composition varies considerably among the different cultivars of Sesame worldwide. The oil contain four major fatty acids namely palmitic, stearic, oleic and linoleic acid along with small quantities of vaccenic, linoleic, arachidic, behenic and eicosenoic acids. Oleic and linoleic acids are nearly in equal amount, constituting about 85 % of the total fatty acids. Cultivars with exceptionally high (60, %) oleic or linoleic acid are rare. It is found that stearic, oleic and linoleic acids content differs between determinate and indeterminate cultivars. Determinate cultivars generally have higher stearic and oleic acids and lower linoleic acid compared to indeterminate ones. Capsule position on the plant also affects the relative quantities of the fatty acids palmitic, stearic and oleic acids tend to increase up the stem while linoleic acid decreases.

The fatty acid composition is strongly influenced by environmental factor, Linoleic acids content has been reported to increase under cool growing conditions, the peroxide Value and Free Acidity increased during storage for five weeks. The iodine value of the Sesame seeds oil decreases as it was

roasted over a period of storage and this suggests the loss of unsaturation in the fatty acids of the triacylglycerol. The antioxidant factors responsible for the stability of roasted Sesame seeds is highly affected by the conditions of the roasting process (Hassan, 2013). The extraction of Sesame oil is done by using three extraction techniques, supercritical fluid extraction, Soxhlet and sequential extraction (Carvalho, Galvao, Barros and Conceicao 2012). The Sesame seed extracts possess high antioxidant activity, the white varieties elicit better antioxidant activity than the black one (Vishwanath, Anilakumar, Harsha, Khanum. and Bawa 2012). Sesame seeds had an average of 0.63 % lignans, making them a rich source of dietary lignans.

Modification of fatty acid composition in sesame oils:

Sesame seed oils have multiple physiological functions such as decreasing arachidonic acid levels and blood lipids. Sesame oil contains a class of unusual compounds known as lignans, comprised of sesamin, sesamolin, a small amount of sesamol, á-tocopherol bioavailability, increasing anti-oxidative ability (Hemalatha, 2004), providing anti-inflammatory function and estrogenic activity also known to have a cholesterol lowering effect in humans and to prevent high blood pressure.

The major edible oils contain predominantly unsaturated 18 carbon fatty acids and palmitic acid a 16 carbon fatty acid. Key target for modification of these oils both for edible and industrial uses have been identified. One goal for modification of these oils for edible use is to increase the amount of palmitic and stearic acids in order to minimize the need of hydrogenation in the production of dietary fats. Another important target is to increase stability of oils, achieved by reducing their levels of unsaturated fatty acids especially linolenic acids. However linoleic and linolenic acids are essential to man and needs to be kept at essentially high levels in dietary fats. The effect of boiling improved the crude fat (49.23 to 56.78 %) and calcium content (757.13 to 975.54 mg/100 g). However, boiling caused a significant reduction in levels of protein (18.87 to 14.12 %), fiber (6.17 to 4.45 %) and potassium (831.47 to 727.42 mg/100 g) while iron levels were unchanged. The total phenolics levels of the raw Sesame seeds (0.15 mg/g) showed a remarkable increase as the boiling

time was increased to 30 min with a level of 0.35 mg/g. In addition, boiling caused a significant increase in the total flavonoid levels from 0.22 mg/g to 0.55 mg/g while a decrease in the vitamin C content of raw Sesame seeds was observed within the period of boiling. Furthermore, the aqueous extracts of boiled Sesame seeds exhibited greater antioxidant properties than that of the raw seeds (Adeniyan, Ibukun ,Ogunbolude.and Eseigbe 2013)

In case of plant industrial oil, there is a wide range of fatty acids of interest including many from wild species that remain a target for commercial production in transgenic crops. Examples of such fatty acids include lauric, petroselinic, ricinoleic, vernolic and ã-linolenic acids. There has been some success with a few of these in oilseed Rape and Soybean but there remain needs to increase quantity of the specific fatty acid for crop effective use of the modified crops. With a better understanding of the biosynthetic pathway for uncommon fatty acid it will be possible to achieve this in the major oil crops. Considering that conventional Sesame oil is beneficial to human health, it seems appropriate that further improvement of quality should focus on producing oils with new dietary, cosmetic, pharmaceutical and nutraceutical uses.

An important requirement for genetic modification of oil composition is the availability of a strongly expressed seed specific promoter. Besides, the promoter should display correct temporal expression of the introduced genes since the synthesis of various storage products is developmentally regulated. In Sesame fatty acid synthesis begins early (9 days after fertilization) during seed development and therefore a late expressing promoter would be unsuitable. Promoter's seed expressed Ä 9 and Ä 12-desaturase genes have been cloned and their expression pattern characterized. These promoters are strong and turn on at the onset of lipid biosynthesis Sesame (Sesamum indicum) is cultivated in several countries such as India, Sudan, China and Burma which are considered as the major producers (60% of its total world production)

Sesame seeds have been used as health food for disease prevention in Asian countries for several thousand years. In some areas in Nigeria mostly in the northern, benniseed is sustainability used The literature reports indicate many health benefits associated with the consumption of sesame

seeds; for example, they significantly increase plasma γ-tocopherol and enhance vitamin E activity, which are believed to prevent human aging-related diseases such as cancer and heart disease. Studies have also shown that including sesame in the diet can improve anti-oxidant capacity Sesame seed has higher oil content (around 50%) than most of the known oilseeds. Sesame oil is generally regarded as high-priced and high-quality oil. It is one of the most stable edible oil despite its high degree of un- saturation. Sesame oil is rich in monounsaturated and polyunsaturated fatty acids, making them ideal candidates for future use in the engineering of Sesame oil composition.

For metabolic engineering of oil quality improvement, fatty acid composition and enzymes involved are very important so we can reduce expression of endogenous enzymes by adding new enzyme, over expressing existing enzyme and by using antisense RNA. It is proved that genes for membrane-bound fatty acid-modifying enzymes not only from plants but also from bacterial, animal, yeast have been shown to function in transgenic plants. The enzymes such as Fatty acid synthase, Thioesterases, Elongases, Desaturases, Stearoyl ACP Desaturase, Ä12-Desaturase, Ä15-Desaturase, Acyl transferases and Hydroxylases are important in fatty acid manipulation. Suppression of the oleateÄ12-desaturase gene (which normally converts 18:1 to 18:2) in Soybean, Sunflower, Cotton and Canola has resulted in the production of oils with a high oleic acid content, which have greater oxidative stability and improved performance in high-temperature cooking applications.

In response to ever increasing world demand of sesame seeds and its oil it is imperative that sesame seeds should be increased production in India. The enough scope exists for increasing area as well as productivity of sesame. Sesame being a number one oilseed in the world due to high nutritional oil through Sesame area in India is more as that of other countries the productivity is far less as sesame can be grown in marginal wastelands due to its ability to adapt to adverseagro climatic conditions. VLC-PUFAs are found in many food applications, including infant formulas, adult dietary supplements, animal feed and food additives, and are used as precursors for the production of pharmaceuticals. The increase in percentage of Omega 3 fatty acids instead of Omega 6 fatty acids might be

possible by using enzymes such as desaturase which can be further helps to improve quality of oil.

Conclusion

Sesame as a valued oil seed appears to have numerous industrial applications. It is therefore important to fully develop Industrial processing and utilization of sesame at a substantial quantity to meet the current demands. In addition to other uses of the oil, like cooking as well as for medicinal purposes such as the treatment of ulcers and burns, the oil extract could equally be used in making soap and skin moisturizers.

Recommendations

Based on the outcome of the production of edible oil from benniseed the following recommendations are made:

A. Government should encourage farmers to plant this crop on a larger scale.
B. School at all levels should be encouraged to plant this crop and government to provide the needed materials
C. Science graduates that are unemployed to be empowered to go into planting of this seed
D. Government to encourage anyone that wants to farm the seed by providing cheap, reliable means of processing the seed into other useful products.
E. Sesame oil can be refined and commercialized for special fatty acid contents in the future.
F. The organic nature of production of the sesame seeds in the country may favour for organic food production of oil which is highly attractive and safe for human consumption. Nigeria can possibly export refined quality oil from sesame in the future.
G. The current breeding system for high oil content of the seed must incorporate
H. Also the different fatty acid compositions in quantity and quality in the future.

I. Private companies engaged in oil seed refining from sesame seed should also incorporate the facilities which could be used to analyze the different fatty acid content.
J. The oil seed extraction companies available in Nigeria are advisable to work closely with the universities and research centres for sesame oil seed analyses especially for different fatty acid contents.

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