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Evaluation of the parameters affecting the extraction of sesame oil from sesame (*Sesamum indicum* L.) seed using soxhlet apparatus

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Keywords

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Abstract

Solvent extraction method was carried out using soxhlet apparatus to extract sesame oil from sesame seed. The primary processing of sesame seed before oil extraction include drying, crushing and separating. These ruptures the oil cells for efficient extraction. Various experiments were carried out regarding different processing parameters like particle size, particle moisture content, nature of the solvent used, pretreatment with salt and extraction time in order to find out their affect on solvent extraction of sesame seed. The results showed that after drying at 105^{o}C, off white variety of sesame seed with an average particle size of 24 mesh and 28 mesh (87.5% and 12.5% in mass respectively) gave maximum oil yield with n-hexane solvent. The extraction was carried out for 4 hours. The physicochemical qualities of the oil were also determined.

Introduction

Sesame oil is an edible vegetable oil derived from sesame (*Sesamum indicu*m L.) an oleaginous seed of the family Pedaliaceae being cultivated in the tropics and the temperate zone (Biabaxi and Pakniyat, 2008). It is one of the oldest oil crops and is widely cultivated in Asia and Africa (Ali *et al*., 2007) primarily for its high oil content and its distinctive flavor. The largest global producers of sesame seed are India, China and Sudan, contributing approximately 60% of world production, almost all of which is used for oil extraction (Abou-Gharbia *et al*., 2000). Though it is called “sesame” internationally, it is called “benniseed” in West Africa, “Sim Sim” in East Africa and “Till” in India and Bangladesh. Natural sesame oil derived from good quality seed has a very pleasant flavor and can be consumed without further purification. The natural oil has excellent stability due to the presence of high levels of natural antioxidants (Lyon, 1972). Sesame oil is rich in oleic and linoleic acids, which together account for 85% of the total fatty acids attributed its effectiveness in reducing blood cholesterol levels. It also contains vitamin E, vitamin K and minerals. It is very rich in lecithin- a phospholipid that acts as a powerful emulsifier, facilitating the dissolution of fat in an aqueous medium (Lichtenstein and Deckelbaum, 2001).

Sesame oil widely consumed as a nutritious food, very beneficial to health as a cooking oil because of its high smoke points. In India and Bangladesh it is used in almost all pickles and condiments. The oil is used widely in the some inject able drug formulations. It is also useful in the industrial preparation of perfumery cosmetics (skin conditioning agents, moisturizer, hair preparations, bath oils, hand products and make up, insecticides, paints and varnishes (Chemonics International Inc., 2002).

Sesame seeds are primarily produced in developing countries, a factor that has played a role in limiting the creation of large scale, fully automated oil extraction and processing techniques (Kamal-Eldin and Appelqvist, 1995). Sesame oil can be extracted by a number of methods depending on the materials and equipment available. In developing countries, sesame oil is often extracted with less expensive and manually intensive techniques such as hot water flotation, bridge process, the ghani process, or by using a small-scale expeller press, large scale oil extraction machines, or by pressing followed by chemical solvent extraction.

This research illustrated the findings of the use of soxhlet extraction method for sesame oil extraction with some pretreatment of sesame seeds using different organic solvents. The results obtained in this study would be applied in industrial extraction to promote the use of selective solvent extraction. The specific objectives of the study were to determine the optimum yield conditions for sesame oil per solvent used and to determine the physicochemical qualities of the sesame oil extract from sesame seed cultivated in Bangladesh.

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Materials and Methods

Materials

The raw materials used for this study were fresh sesame (*Sesamum indicum* L.)seed of three varieties in off white, black and brown colour collected from local farmers of Bangladesh. The solvents and reagents used were purchased from Sigma Aldrich Chemie GmbH, Germany.

Preparation of raw material

Sesame seed was dried in an oven at 70^{0}C and 105^{0}C then crushed and separated into the particle size with an average of 24 and 28 mesh (87.5 and 12.5% in mass respectively) using Tyler Series sieves for soxhlet extractions.

Soxhlet Extraction

Soxhlet extractor EX5/55/100 100 ml Quickfit Glass, England and Whatman high performance cellulose extraction thimbles were used for sesame oil extraction. The extraction was carried out for 4 hours as described by Visavadiya *et al.* (2009) maintaining solvent to solid ratio at 25:1. Petroleum ether (40-60^{o}C), n-hexane, ethanol and carbon tetrachloride had been used as solvent. All experiments were performed in triplicates to better assess the results. After extraction the solvents were evaporated under vacuum at 40^{o}C under reduced pressure using a rotary vacuum evaporator (model- Tokyo Rikakikai Co. Ltd. Eylea) with vacuum control (Bozan and Temelli, 2002; Visavadiya *et al*., 2009).

Methods

Moisture, specific gravity, iodine value, saponification value, acid value and peroxide value were determined according to the method described by IUPAC (1979).

Results and Discussions

Effect of solvents on oil extraction

Figure 1 presents the yields (oil mass/raw material mass) of the extractions for sesame oil, obtained from sesame seed samples of three varieties off white, brown and black with an average particle size of 24 and 28 mesh (87.5% and 12.5% in mass respectively). The selection of solvent for oil extraction was done on the basis of soxhlet extraction. Results revealed that n-hexane was the best solvent than other solvents used like petroleum ether, ethanol and carbon tetrachloride (CCl_4). The maximum yield achieved was 46% of with n-hexane and minimum yield achieved was 41% of with CCl_4 for off white variety of sesame seed. In all cases of extraction using different solvents three varieties were used and it was found that with the off white variety maximum yield was achieved on the basis of its extraction capacity, low viscosity, higher solubility with the oil and nearly equal polarity of the solvent and the oil.

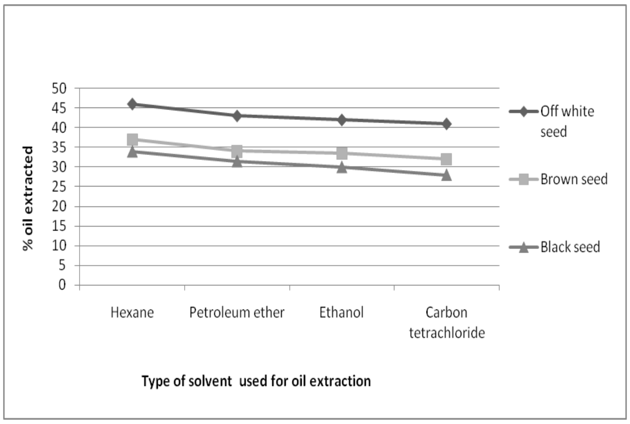

Figure 1. Effect of solvent on sesame oil extraction from sesame seeds of three varieties

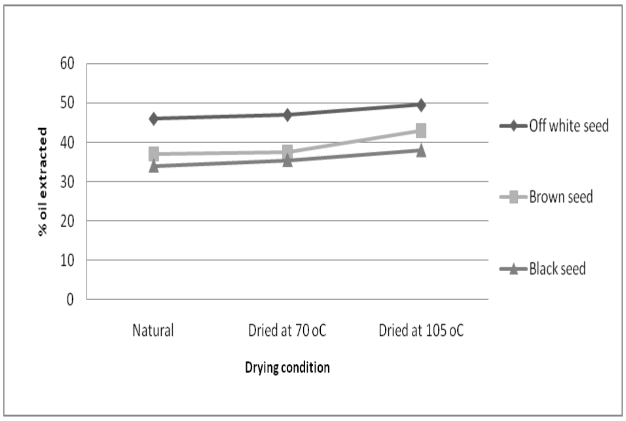

Figure 2. Effect of drying on sesame seed oil extraction using n-hexane

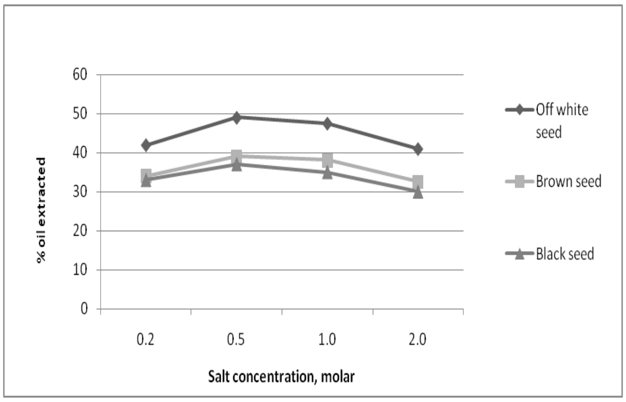

Figure 3. Effect of pretreatment with NaCl on sesame seed oil extraction using n-hexane

Table 1. Physicochemical properties of sesame seed oil* at zero time of storage

Parameter No.	Parameter	Sesame Seed Oil of three varieties		
		off white	Brown	Black
1	Moisture content (%) (raw seed)	5.23	4.25	3.45
2	Specific gravity	0.92	0.92	0.92
3	Iodine value (g/100 g oil)	112	112	111
4	Saponification value (mg KOH/g)	190	189	190
5	Acid value (mg KOH/g)	0.78	0.68	0.71
6	Peroxide value (meq/kg oil)	4.8	5.1	5.3

*The values are mean of triplicates determinations

Effect of drying on sesame oil extraction using n-hexane

Drying caused removal of the moisture content from the oil seed and thus resistance to the oil extraction was reduced. Heat also reduced the oil viscosity and releases oil from intact cells. The drying process facilitates the crushing of seeds. Drying before extraction helps rapture the seed walls and thus the solvent can more readily dissolve into the wall. It was observed that by increasing the drying temperature from 70°C to 105°C all the moisture content from the sesame seed was removed and the yield of oil was increased by 2.5%, 5.5% and 2.5% for off white, brown and black sesame seed varieties respectively. The results are shown in the Figure 2.

Effect of pretreatment with sodium chloride (NaCl) on sesame seed oil extraction

Pretreatment of sesame seeds with aqueous NaCl solution was done for all three varieties which are shown in Figure 3 and n-hexane was used as solvent to extract oil from pretreated seed. The percentage of oil extracted was increased with the increase of molar concentration and gave the highest yield (49%) for pretreated sesame seed of off-white colour with 2M NaCl solutions after that a further increase of salt concentration lead to decrease in the oil yield.

Effect of extraction time over the oil yield

The effect of extraction time assessed over the oil yield on soxhlet extraction using n-hexane. The percentage of oil extracted increased sharply for first two hours of extraction. It peaked at about 42% yield at second hour of extraction after that the oil yield inclined slowly and remained constant at 49.5% from fourth hour. Two steps involved in the extraction process, in the first step of extraction the yield was risen rapidly from external surface. However in the second step of extraction comparatively slow extraction was observed from the inner particle. The off white variety was found as the most suitable variety of sesame seed for maximum oil yield (49.5%) after 4 hours of extraction.

Physicochemical quality of the oil extracted from sesame seed

An analytical comparison of the oil extracted from the three varieties of sesame seeds are summarized in Table 1. Several indices are used for the determination of oil Quality. For the purpose of this experiment different parameters were analyzed. Sesame seed has higher oil content (around 50 %) than most of the known oil seeds (Hwang, 2005). The seed has 40-60 % of oil with almost equal levels of oleic (range 33-50%, typically 41%) and linoleic acids(range 33-50%, typically 43%) and some palmitic acid (range 7-12%,typically 9%) and stearic acid (range 3-6%,typicaly 6%) (Gunstone, 2004).

Iodine value

The iodine value of sesame seed was found from 111 to 112 g/100 g oil for three varieties which was within the expected iodine value range (103-120). Since the result meets the range outlined by the method used, it can be considered that the oil extracted has good stability.

Saponification value and acid value

Saponification value (SV) in combination with the acid value provides information on the quality, type of glycerides and mean weight of the acids in a given sample. SV value is of interest if the oil is for industrial purpose. The larger the saponification number the better the soap making ability of the oil (Nielsen, 1994). SV value of sesame seed of three varieties was found from 189 to 190 mg KOH/g. While it was found that the sesame oil had low acid value (0.68-0.78 mg KOH/g) which mean that the oil contained less free fatty acids thus reducing its exposure to rancidification (Roger *et al*., 2010; Asuquo et al., 2012; Anderson-Foster *et al*., 2012). Higher SV value and low acid value indicates the edibility of oil as well as their suitability for industrial use.

Peroxide value

Peroxide value (PV) is the most frequent

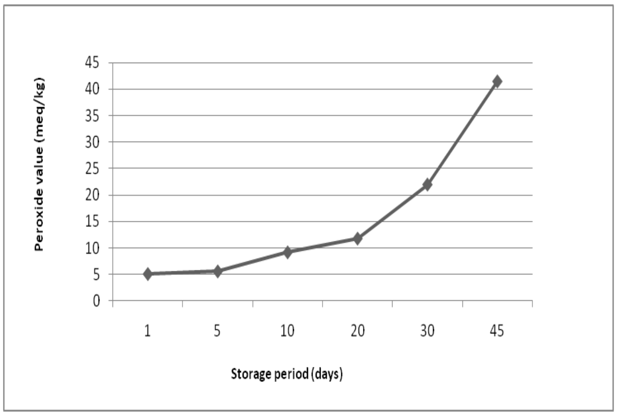

Figure 4. Change in peroxide value on sesame oil extracted using n-hexane

measurement of lipid oxidation. Hydroperoxides have no flavor or odor of their own, but they are not stable and split up rapidly to other products such as aldehydes that have a strong, disagreeable flavor and odor (Shahidi, 2005). It is used to assess in what extent rancidity reactions have been occurred during storage, it could be used as an indication of the quality and stability of fats and oils (Ekwu and Nwagu, 2004). The PV value was found between 4.8 and 5.3 meq/kg oil for three varieties of sesame seed. Oils exposed to both atmospheric oxygen and light showed a dramatic increase in peroxide value during storage. The PV value obtained for raw sesame seed was about 50 meq/kg oil for 50 days of storage at 65^{o}C (Elleuch *et al.*, 2007). A significant change of peroxide value with storage time had been observed which are shown in Figure 4. The PV value had been changed dramatically from 5.1 to 42 within 45 days storage. Auto oxidation reactions may occur quickly in oils that have primarily unsaturated fat molecules and the reactions take place at an increasing rate after the initial induction period (Aluyor and Ori-Jesu, 2008). The oxidation of oil could be prevented with the inclusion of a natural or synthetic antioxidant (Bera *et al*., 2006). Synthetic antioxidants such as Butylated hydroxyanisole (BHA), Tertiary butyl hydroquinone (TBHQ), or Butylated hydroxytoluene (BHT) recommended by FAO/WHO may be incorporated in order to enhance the storage properties of oil (Codex Stan 210, 1999).

Conclusions

This work explores the extraction of the sesame seeds using various organic solvents. Particle size, particle moisture content, nature of the solvent used, pretreatment with salt and extraction time influenced on extraction yield. The n-hexane was found to be the suitable solvent for the extraction of the sesame oil. Sesame seed oil has several applications including industrial, cooking and medicinal purposes. Hence development of industrial processing and use of sesame at a large quantity is necessary in order to meet the current demands.

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