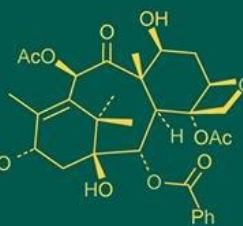
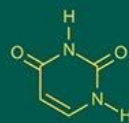


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Effect of extraction temperature and roasting time on quality characteristics of sesame oil

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Abstract

Studies were focused on influence of extraction temperatures and roasting time on quality characteristics of sesame oil. The sesame seeds are roasted at 60 °C for different roasting timings i.e. 15, 30, 45 and 60 min. respectively. Then the pretreated samples are fed into Mini oil expeller at different extraction temperatures i.e. 80, 100 and 120 °C respectively for extraction of oil. The oil samples are then analyzed for physical and chemical characteristics of oil. Results showed that the percentage of oil extracted in Mini oil expeller is higher at 80 °C extraction temperature, 60 min. roasting time followed by 45, 30 and 15 min. respectively. The lowest percentage of oil extracted at 120 °C extraction temperature, 15 min. roasting time followed by 30, 45 and 60 min. respectively.

Keywords: Sesame seeds, mini oil expeller, roasting time, extraction temperatures, quality

1. Introduction

Sesame (*Sesamum indicum* L.) is an herbaceous oilseed crop of the pedaliaceae family. Sesame is also known as sesamum, gingelly, beniseed, sim-sim. Sesame seeds contain 50-60% oil, 18-25% protein, 13.5% carbohydrate and 5% ash (Elleuch *et al.*, 2007) [10]. 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 unsaturation. Sesame oil highly resistant to oxidative deterioration, even though it is unsaturated. The stability of sesame oil is due to the presence of endogenous antioxidants, sesamin, sesamol and sesamol. 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. The seeds from north-east region of India are black; those from eastern region are brown to black and from south are predominantly red or reddish brown. Seeds from other regions are white. White and black seeded strains, on an average contain 55% and 47.8% oil respectively.

Sesame oil is regarded as a high-priced and high-quality product. It contains approximately 14% saturated, 39% monounsaturated and 46% polyunsaturated fatty acids (Jain, 2020) [11]. Sesame oil has a long shelf life compared to others vegetables oils, even when stored at ambient temperatures, despite its high degree of unsaturation. This is attributed to endogenous antioxidants which include mainly γ -tocopherol, lignans such as sesamol, sesamol or sesamin and other phenolic derivatives (Dossou *et al.*, 2021) [9]. Recent studies have reported that the consumption of sesame or sesame products can improve human health, including anti-inflammatory and anticarcinogenic effects, blood pressure and serum lipid-lowering effects, inhibiting in vitro malignant melanoma growth and human colon cancer cell proliferation and increasing the bioavailability of γ -tocopherol.

Mechanical screw pressing is the most popular method of oil separation from oil seeds in the world. Nearly 90% of the total oil seeds produced in India are crushed using this method. Applied pressure, heating temperature, heating duration, moisture content, particle size, handling and storage are factors influencing yield and quality of oil expression. The degree of influence varies with kind of oil seeds and method of oil expression. The advantage of expression over extraction processing is that it gives products free of dissolved chemicals and inherently, a safer process (Khan and Hanna, 1983) [13]. Roasting is a key step in the oil industry which results in important physical, chemical, structural and organoleptic changes (Zhang *et al.*, 2021) [25].

This process was reported to increase the yield of extracted oil, its lignan contents and its antioxidant activity (Park and Kang, 2004) [20]. The nutritional quality and composition of the oils, as well as their sensory characteristics and acceptability by consumers, are affected by the roasting temperature Yin *et al.*, 2020 [23]. During the roasting process, seeds become more crumble and brittle. Changes in roasting temperature have been reported to produce brown pigments. Non-enzymatic browning and phospholipids degradation are responsible for color formation in sesame oil. According to Yoshida *et al.* 2000 [24], increases in roasting temperature caused losses in sesamin (from 7271 to 6902 mg/Kg of oil roasted at 220 °C for 25 min) and sesamol (from 4605 to 2873 mg/Kg of oil at 220 °C for 25 min). Tocopherol was still present at more than 80% of its original value after roasting for 25 min at all temperatures. The effects of roasting at high temperatures are complex. It causes the liberation of free fatty acids by hydrolysis of mono-, di- and tri-acylglycerols which can accelerate the process of oil oxidation, leading to poor oil quality. However, roasting also favors the development of colored products, and is reported to possibly participate in the prevention of lipid oxidation (Zhang *et al.*, 2021) [25]. It cleaves and liberates phenolic compounds (Jeong *et al.*, 2004) [12], for instance, the lignan sesamol can be degraded into other phenolic compounds with higher antioxidant potential (Kumar *et al.*, 2009) [15].

Sesame oil prepared from roasted sesame seeds has a distinctive flavour and longer shelf-life (Manley *et al.*, 1974; Kikugawa *et al.*, 1983) [14] and is used as cooking oil and in shortenings and margarines. A higher roasting temperature has usually been used to obtain a strong flavour, but it results in a sesame oil of poorer quality (Yen *et al.*, 1986) [22]. Hence, there is a need of intense search for safe and natural antioxidants that can slow the oxidative deterioration of lipids, improve their quality and keep their nutritional worth. Keeping the above points in view, a study was undertaken to study the effect of extracting temperature and roasting time on quality characteristics of sesame oil.

2. Materials and Methods

The fresh sesame seed was collected from the local market. The initial value of moisture content 4.3% (wet basis). The Mini oil expeller was used for extraction of oil at different temperatures of 80, 100 and 120 °C. Sesame seeds are pretreated at different roasting time (15, 30, 45 and 60 min) by using incubator at 60 °C before feeding into the Mini Oil Expeller. This expeller consists of temperature adjustment device using the heating conductor to adjust the temperature. And also contains screw mechanism through which the cake is sent outside. The temperature of the expeller should be maintained constant randomly at 80, 100 and 120 °C before the sesame seeds are fed into the expeller and the temperature is maintained constant with an error of about ± 2 °C throughout the extraction process. The roasted sesame seeds are feed in to the conical hopper and operated at forward speed then the sesame oil is collected into a bottle from the bottom of the expeller and the cake is collected from the front of the expeller. Before collecting the oil in the bottle and cake in the plate the weight of the empty bottle and the empty plate is measured and noted. The oil extracted may contain impurities and hence the oil collected may pass into the filter paper. After extraction of the oil and cake at different temperatures i.e. 80, 100 and

120 °C then the expeller is let to cool down and the screw press is removed with care and it should be cleaned thoroughly with water so that there is no sediment left in the press and let the press is completely dried. The experimental procedure is repeated again for other pretreated samples.

2.1 Experimental procedure for extraction of sesame oil

The process flow chart for extraction of sesame oil is as shown in Fig 1.

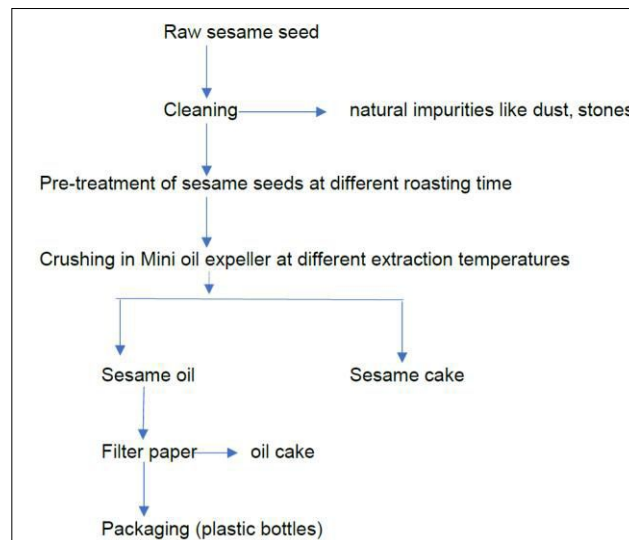


Fig 1: Process flow chart for extraction of oil from sesame seed

2.2 Determination of physico-chemical properties

2.2.1 Determination of Moisture Content

Moisture content of the green chillies while drying on tray dryer is measured (AOAC, 2005) [5]. The samples are taken in moisture boxes from each lot to determine the moisture content. The boxes were kept in hot air oven at 105 ± 3 °C for 24 hours and the weights are measured on electronic digital weighing balance having an accuracy of 0.01 g. From the initial and final moisture box weights, the moisture content of sample is determined and expressed in percentage (%) by using the following formula:

$$\text{Moisture content (w.b.)} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100$$

W_1 = Weight of the empty box, g

W_2 = Weight of the moist sample + box,

W_3 = Weight of dried sample + box, g

2.2.2 Oil recovery

The percent of oil recovered was determined by employing the use of the following equation:

$$\text{Percent oil yield} = \frac{W_{OE}}{W_S} \times 100$$

Where,

W_{OE} = weight of oil expressed (g)

W_S = weight of sample before expression

2.2.3 Bulk density

The bulk density of sesame oil is measured by standard AOAC, 2005 method.

$$\text{Bulk Density} = \frac{W_1 - W_2}{V}$$

Where,

W_1 = weight of empty glass beaker

W_2 = weight of glass beaker with oil

V = volume of oil taken = 5 mL

2.2.4 Peroxide value

The peroxide value is defined as the amount of peroxide oxygen per 1 kilogram of fat or oil. Traditionally this was expressed in units of milliequivalents, although using SI units then the appropriate option would be in millimoles per kilogram. Detection of peroxide gives the initial evidence of rancidity in unsaturated fats and oils. Other methods are available, but peroxide value is the most widely used. It gives a measure of the extent to which an oil sample has undergone primary oxidation.

Peroxide values of fresh oils are less than 10 milliequivalents/kg; when the peroxide value is between 30 and 40 milliequivalents/kg, a rancid taste is noticeable. The peroxide value is determined by AOCS, 2004 [7].

$$\text{Peroxide value} = \frac{V \times N \times 1000}{W_s}$$

Where,

V = volume of sodium thiosulphate

= final burette reading - initial burette reading

N = Normality of sodium thiosulphate $\text{Na}_2\text{S}_2\text{O}_3$

W_s = Sample weight, g

2.2.5 Iodine value

Iodine value (IV) is a measure of the total number of double bonds present in fats and oils. It is expressed as the "number of grams of iodine that will react with the double bonds in 100 grams of fats or oils". The iodine value (IV) indicates the degree of unsaturation of a fat or oil. It is defined as the number of grams of iodine absorbed by 100 g of fat.

Iodine value is used to measure unsaturation or the average number of double bonds in fats and oils. A high, iodine value indicates high unsaturation. The most important application of the iodine value is to determine the amount of unsaturation contained in fatty acids. This unsaturation is in the form of double bonds which react with iodine compounds. The higher the iodine value, the more unsaturated fatty acid bonds are present in an oil. Iodine value is used as a parameter in process control. The iodine value is determined by AOCS, 2004 [7].

The formula for finding the iodine value is

$$\text{Iodine value} = \frac{12.69 \times (V_B - V_s) \times N}{W_s}$$

Where,

N = Normality of sodium thiosulphate solution = 0.1

W_s = Weight of the oil sample = 0.27 g

V_B = Volume of sodium thiosulphate for the blank solution
= Final burette reading - initial burette reading

V_s = Volume of sodium thiosulphate for the sample solution
= Final burette reading - initial burette reading

2.2.6 Acid value

The acid value is defined as the number of milligrams of Potassium hydroxide required to neutralize the free fatty acids present in one gram of oil. It is a relative measure of rancidity as free fatty acids are normally formed during decomposition of triglycerides. The acid value of oil may be used as a measure of quality. However, the acid value of the oil must not be too high, as this denotes an excessively high content of free fatty acids, which causes the oil to turn sour. Discoloration may also occur. Sesame oil should have an acid value of at most 1.0-1.4%.

The acid value is determined by AOCS, 2004 [7]

$$\text{Acid Value} = \frac{MW_{\text{NaOH}} \times N \times V}{W_s}$$

Where,

W_s = Sample weight = 10 g

N = Normality of NaOH = 0.1

V = Volume of NaOH solution

= Final burette reading - initial burette reading

MW_{NaOH} = Molecular weight of NaOH = 40

2.2.7 Saponification value

Saponification value is the number of mg of potassium hydroxide required to neutralize the free acids and to saponify the esters in 1 g of the oil. It is a measure of the free and esterified acids present in fats and fatty acids. The acid value is determined by AOCS, 1990 [6].

$$\text{Saponification value} = \frac{28.05 \times (\text{titre value of blank} - \text{titre value of sample})}{\text{weight of sample (g)}}$$

3. Results and Discussion

3.1 Effect of roasting time and extraction temperatures on oil yield

The results showed the effect of roasting time for 15, 30, 45 and 60 min at extraction temperatures of 80, 100 and 120 °C. The experiment was carried out at moisture content of 4.3-4.5%. The unroasted seeds (control) had an oil yield of 28.9%. It can be seen from Figure 2, as the temperature increases, the percentage of oil yields getting decreased. Theoretically, oil yield would be increased with the increase of heating temperature and pressure extraction. However, under a certain level, the increase of heating temperature and pressure extraction will probably decrease the amount of oil yield (Adeeko and Ajibola, 1990) [2]. The reason of percentage of oil yield get reduced at higher temperature might be due to the change of moisture content and structure of the seeds during the heating process which this condition actually related to the production of oil (Ogunsina *et al.*, 2008) [19].

It could be observed from the Figure 2 that the oil yield increased with the increase in roasting time of 15, 30, 45 and 60 min. at different extraction temperatures. The highest oil yield (48%) was found at extraction temperature 80 °C of roasting time 60 min. whereas the lowest oil yield (30%) was found at extraction temperature 120 °C of roasting time 15 min. respectively. This increasing trend might be due to the rupture of cell walls and expulsion of the oil. These findings are in agreement with Akinose *et al.*, 2006.

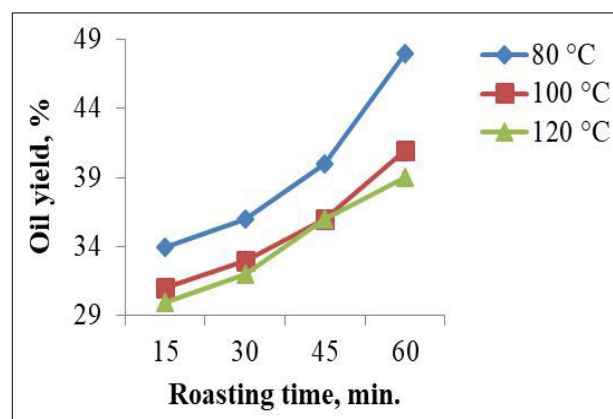


Fig 2: Effect of roasting time and extraction temperatures on oil yield

3.2 Effect of roasting time and extraction temperatures on bulk density

It could be observed from the Figure 3, the bulk density decreased with increase in roasting time and temperature. The lowest bulk density (836 kg/m^3) was observed at extraction temperature 120°C , roasting time 60 min. whereas the highest bulk density (882 kg/m^3) was observed at extraction temperature 80°C , roasting time 15 min. respectively. The control sample has higher bulk density value (898 kg/m^3) as compared to the other pretreated samples. The decreasing trend of bulk density may be due to the fact that an oil bearing seed tends to lose some of its properties such as weight when heated hence resulting in lower density.

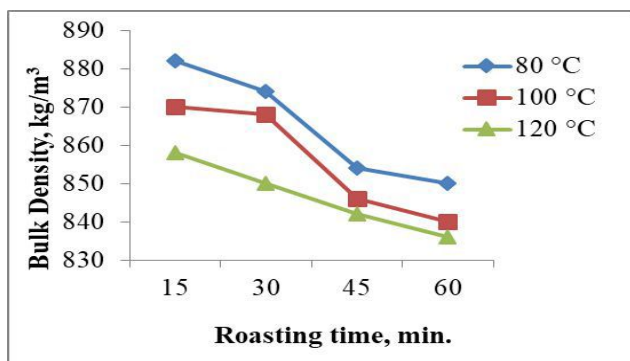


Fig 3: Effect of roasting time and extraction temperatures on bulk density

3.3 Effect of roasting time and extraction temperatures on peroxide value

The peroxide values were obtained in the range of 7.7-8 meq/kg. It was observed from Figure 4 that the peroxide values decreased with increased extraction temperatures. Also observed that the peroxide values increased with increase in roasting time. The lower peroxide value (7.7 meq/kg) was found at extraction temperature 120°C , roasting time 15 min. whereas the higher peroxide value (8 meq/kg) was found at extraction temperature 80°C , roasting time 60 min. respectively. The control sample has higher peroxide value (8.25 meq/kg) as compared to the other pretreated samples. Peroxide value is used to monitor the development of rancidity through the evaluation of the quantity of peroxide generated in the product (initiation product of oxidation). The peroxide value is usually less than 10 per gram of a fat sample when the sample is fresh. The lower peroxide value indicates its resistance to rancidity.

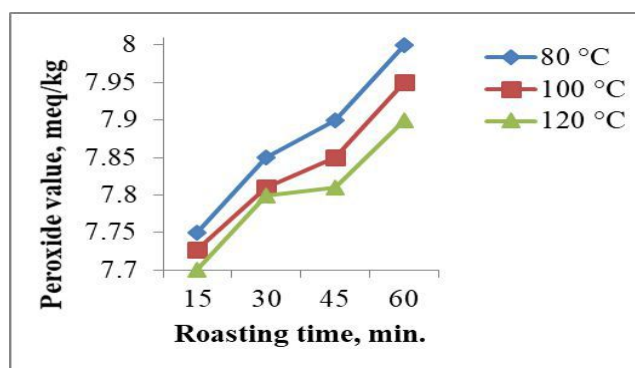


Fig 4: Effect of roasting time and extraction temperatures on peroxide value

3.4 Effect of roasting time and extraction temperatures on acid value

The acid values were obtained in the range of 0.56-0.62 mgKOH/g. It was observed from Figure 5 that the acid values increased with increased extraction temperature and roasting time. The control sample has higher acid value (0.695 mgKOH/g) as compared to the other pretreated samples. The lower acid value (0.56 mgKOH/g) was found at extraction temperature 80°C , roasting time 15 min. whereas the higher acid value (0.62 mgKOH/g) was found at extraction temperature 120°C , roasting time 60 min. respectively. The increasing trend of temperature may be due to splitting of the oil molecules into fatty acids and glycerol as temperature increased (Nwabanne and omoniyi, 2010) [17]. Moisture content and lipase activity in the oil seeds could be controlled by thermal process such as heating (Bargale, 1997) [8].

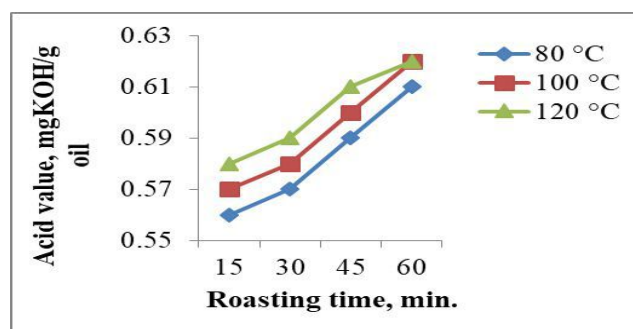


Fig 5: Effect of roasting time and extraction temperatures on acid value

3.5 Effect of roasting time and extraction temperatures on iodine value

The iodine values were obtained in the range of 106.22 to 110.45 g Iodine/100 g. It was observed from Figure 6, that the iodine values decreased in a uniform manner with an increase in extraction temperature and roasting time. The control sample has higher iodine value (113.57 g Iodine/100 g) as compared to the other pretreated samples. The lowest iodine value (106.22 g Iodine/100 g) was obtained at extraction temperature 120°C , roasting time 60 min. whereas the highest iodine value (110.45 g Iodine/100 g) was obtained at extraction temperature 80°C , roasting time 15 min. respectively. It can be seen that the iodine value decreased with increase in temperature indicating a decrease in unsaturation of the oil which may be due to the polymerization of the oil molecules (Nwabanne and omoniyi, 2010) [17].

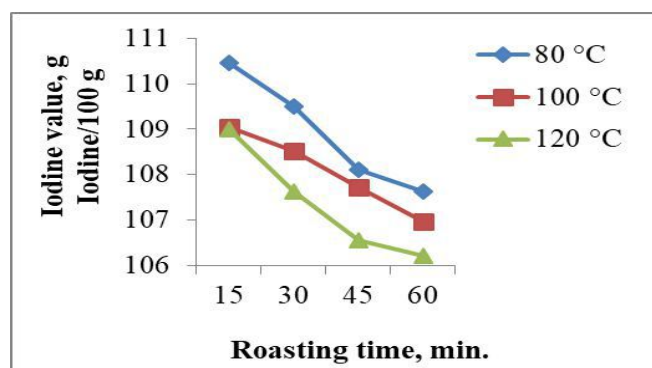


Fig 6: Effect of roasting time and extraction temperatures on iodine value

3.6 Effect of roasting time and extraction temperatures on saponification value

The saponification values were obtained in the range of 189.12-191.50 mgKOH/g. It was observed from Figure 7 that the saponification values decreased with an increase in extraction temperature. Also observed that the saponification values increased with an increase in roasting time. The control sample has higher saponification value (193 mgKOH/g) as compared to the other pretreated samples. The lowest saponification value (189.12 mgKOH/g) was obtained at extraction temperature 120 °C, roasting time 15 min. whereas the highest saponification value (191.50 mgKOH/g) was obtained at extraction temperature 80 °C, roasting time 60 min. respectively. In fact, the saponification value is a measure of the average molecular weight of the triglycerols in an oil sample. It means that the saponification value is inversely proportional to the mean molecular weight of fatty acids. The oils with high saponification values contain high proportion of lower fatty acids and can be regarded as edible oils. These findings are in agreement with the findings of Adejumo *et al.*, 2013 [1].

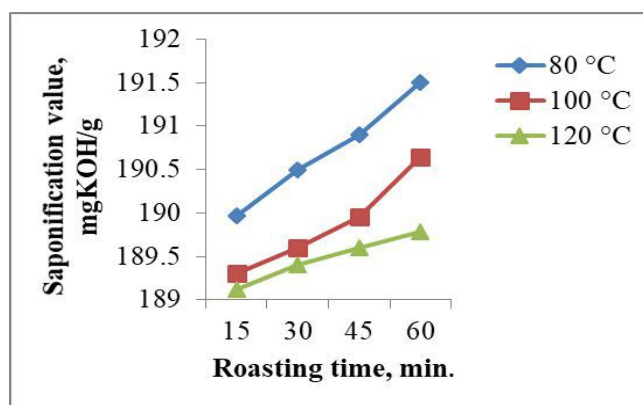


Fig 7: Effect of roasting time and extraction temperatures on saponification value

4. Conclusion

The effect of the roasting process on white sesame seeds was evaluated in this study. As the roasting temperature increased, the composition and content of fatty acids and antioxidant phytochemicals changed significantly. Results found that the oil yield is more at lower extraction temperature and higher roasting time. It was concluded that the acid values, saponification values increased while the peroxide and iodine values decreased in a uniform manner with increased extraction temperature and roasting time. The extracted oil from roasted seeds in optimum conditions can be used as beneficial natural additives to fresh meat products to extend shelf life during cold storage. The results of this study may help to increase the nutritional value of plant-based diets by facilitating the use of roasted sesame seed oil and its components.

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