Effects of processing parameters of Roselle seed on its oil yield

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Abstract: The effect of the processing parameters of Roselle seed on its oil yield was investigated. The seeds were ground and classified into two particle sizes (fine and coarse) using ASAE Standard S319.3. The samples were conditioned by adding calculated amount of distilled water to different moisture levels from the initial moisture levels of 4.4% and 5.14% respectively, (fine, 4.4%, 6.4%, 8.4% and 10.4% and coarse samples 5.14%, 7.14%, 9.14% and 11.14%w.b.). The samples were heated at different temperatures of 80, 90, 100 and 110℃ over a period of 15, 20, 25 and 30 min, expressed at 15, 22.5, 30 and 37.5 MPa using hydraulic oil extractor for 10, 20, 30 and 40 min. Oil yield increases by 5%–6% with an increase in the processing parameters of pressure up to 30 MPa, temperature of 100℃ and decreased beyond these points. Oil yield increased by 7% – 8% with an increase in moisture content. Finely ground samples were found to have higher yield than coarsely ground samples at the different processing parameters. Processing parameters were found to affect the yield of oil from Roselle seeds.

Keywords: Roselle seed, moisture level, temperature, pressure, hydraulic oil extractor.
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1 Introduction

Particle size, heating temperature, heating time, moisture content, applied pressure and pressing time affects the yield of fats and oil during expression[1]. For maximum oil recovery and least residual oil in the cake, it is necessary to control these factors during the oil or fat expression process. Inability to control them could lead to failure in getting high yield and good quality fats and oil during expression.

Oil yield was found to increase with increase in heating temperature levels of 60℃, 90℃ and 120℃[2]. An increase in temperature reduces the viscosity of oil and improves the oil flow. However it was reported that at 120℃, heating time beyond 15 min most especially at heating time of 25 min resulted in oil yield losses of about 12.3%. The rate of oil expression from groundnut seeds was increased by increasing temperature and time of heating[3]. An increase in heating temperature increased the oil yield of samples heated for 15 and 25 min. For samples heated for 35 and 45 min, there was no significant difference in the yield of oil from samples heated at different temperatures. Oil yield from samples heated at 135℃ was highest at 15 min and further increase in heating time decreased the yield. Samples heated at 160℃ increased in yield from 33% to 37% when heating time was increased from 15 to 25 min. A further increase in time of heating led to a decrease in yield.

Reports from work carried out on sunflower kernels showed that unheated sunflower kernels gave a lower oil yield when compared with heated and conditioned samples[4]. Reports from investigation carried out on mechanical expression of oil from conophor nut showed that oil yield increased from 50–65℃ but decreased with increase in heating temperature to 110℃[5]. It was observed that samples became more hardened with increasing heat treatment, thereby offering increased

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resistance to pressure application during expression, thus the decrease in oil yield. High oil yield was obtained at heating time of 20 and 28 min for samples heated at 65, 80 and 95℃. The highest oil yield of 39.6% was obtained when sample was heated at 65℃ for 28 min.

The maximum oil recovery was obtained when sunflower seeds were expressed at 6% moisture content and increasing the moisture content to 14% decreased oil recovery by 16%[6]. As the moisture content of groundnut increased up to 6%, the percentage oil removed increased and the yield decreased beyond 6% moisture content[7]. A moisture content of 9% was found to be optimum for expression of oil from avocado fruit[8]. In the case of canola seed, moisture content in excess of 9% adversely affected the oil yield[9]; while 10% moisture content and 11% moisture content gave the maximum oil recovery for unsieved rice bran and sieved rice bran respectively[10].

It was reported that increase in moisture content led to increase in yield of oil for sunflower kernels from 53.2% to 58.2%[4]; while maximum oil could be obtained from grated coconut if the moisture content of expression falls within 10.9% to 12.9%[11].

During the process of oil expression from oilseeds, increasing the pressure applied during screw pressing tended to decrease the size of the capillaries through which oil flows and further increase in pressure may eventually lead to the sealing of the capillaries[12].

The amount of oil expressed from groundnut tended to level off after three minutes of pressing at a pressure of 13.8 MPa[13]. Oil yield from groundnut was found to increase with increase in pressure up to 20 MPa beyond which the yield leveled off, but decrease in oil yield observed at 25 MPa may be due to the sealing of some inter kernel voids at this pressure[3].

There was a significant increase in oil yield from melon seeds when applied pressure was increased from 5 to 18 MPa but oil yield either leveled off or decreased slightly when the pressure was increased to 25 MPa[14]. The relatively constant yield with an increase in pressure from 15 to 25 MPa may be due to the sealing of some inter kernel voids beyond 15 MPa. There was an increase in oil yield from conophor nuts as pressure increased from 10 MPa to 25 MPa[5]. The maximum oil yield of 39.6% was obtained at an applied pressure of 25 MPa and pressing time of ten minutes.

Much work had not been done on oil extraction from Roselle seed compared to other oil bearing seeds. This work therefore considered the effect of processing parameters on the yield of oil from Roselle seed.

2 Materials and methods

The Roselle seeds were ground using a burr mill and the particle size characteristics were determined by using the ASAE standard S319.3[15]. Silica (0.05%) was added to the sample to act as a dispersing agent.

Fine and coarse samples of the ground Roselle seeds as shown in Figures 1 and 2 were conditioned to the moisture contents of 4.4%–10.4 % and 5.14%–11.14 % with 2% increment respectively. The conditioned samples, 40 g each, were kept in cloth wrapped with polythene bags and stored in a refrigerator set at a temperature of (4±1)℃ for a period of 15 h to allow for even distribution of moisture content. The samples to be expressed were removed from the refrigerator and kept in a desiccator to prevent moisture loss prior to heating. They were heated by spreading in a thin layer in a closed container placed in a preset temperature controlled oven at the different heating temperatures of 80, 90, 100 and 110℃ over a period of 15–30 min at an increment of five minutes. A thermometer was used to measure the oven temperature to ensure that it is maintained at the required level. Oil was expressed at applied pressures of 15–37.5 MPa at 7.5 MPa intervals using hydraulic oil extractor for between 10 – 40 min at increment of 10 min.

Figure 1 Fine sample of the ground Roselle seed

Figure 2 Coarse sample of the ground Roselle seed

The expressed oil was collected in a container initially weighed by a digital balance having a sensitivity of 0.01 g before the oil expression. The oil yield was calculated as the ratio of the difference between the weights of the unexpressed and expressed samples to the maximum oil yield obtainable from the seed which were converted to percentages.

3 Results and discussion

As shown in Figure 3, there was a general increase in the oil yield as the pressure increased from 15 to 37.5 MPa. This was observed to be the trend within the range of heating temperatures at lower moisture contents of 4.4% and 5.14% respectively for the finely ground and coarsely ground. Similar trends were observed during oil expression from sesame seed and soybean[16,17]. The oil yield from the coarse samples increased steadily at temperatures of 80, 90 and 110℃. At 100℃ the oil yield decreased after a pressure of 30 MPa as shown in Figure 4. A similar trend was reported for soybeans[18].

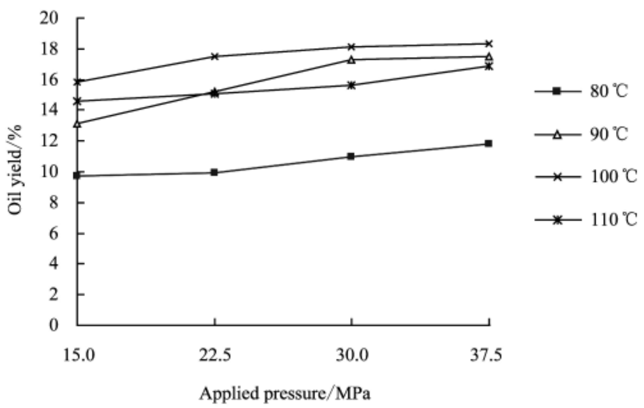

Figure 3 Effects of applied pressure on the oil yield from finely ground Roselle seed at different temperatures heated for 20 min and expressed for 20 min

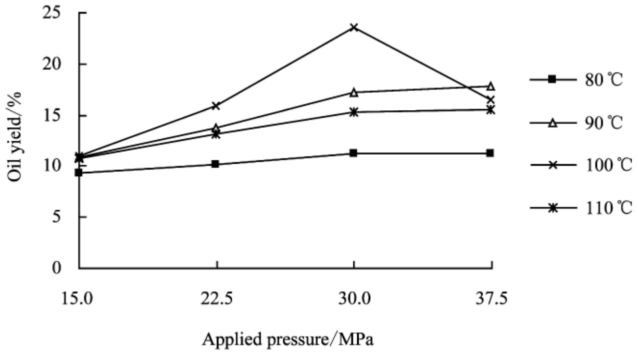

Figure 4 Effects of applied pressure on the oil yield from coarsely ground Roselle seed at different temperatures heated for 20 min and expressed for 20 min

The oil yield from the finely ground seeds were higher than those of the coarsely ground samples at all the applied pressure levels. This increase in oil yield is attributed to the fact that samples the oil cells were broken to allow the free flow of the oil from these cells when pressure was applied and hence an increase in the oil yield. This indicates that particle size has an effect on the yield of oil.

These results were similar to those reported by other researchers[5,18] during the expression of soybean and conophor nut oils.

A decrease in oil yield was observed as the applied pressure increased from 30 to 37.5 MPa at the various levels of heating temperature with increase in heating time as shown in Figures 5 and 6 for the finely and coarsely ground Roselle seeds. There were steady increases in the oil yield from these samples up to 30 MPa before the yields started decreasing. This could be attributed to the fact that increasing the pressure applied on oilseeds during oil expression could narrow, shear, and may eventually seal the capillaries through which oil drains out during oil expression causing reduction in the oil yield despite the fact that there has been an increase in the applied pressure[12].

This phenomenon was also observed during the mechanical expression of oil from groundnut where the oil yield increased significantly when the applied pressure increased from 10 to 20 MPa with a slight decrease as the pressure was increased to 25 MPa. A similar report was given during the melon seed oil expression[14]. They attributed this to the sealing of some inter kernel voids at this pressure.

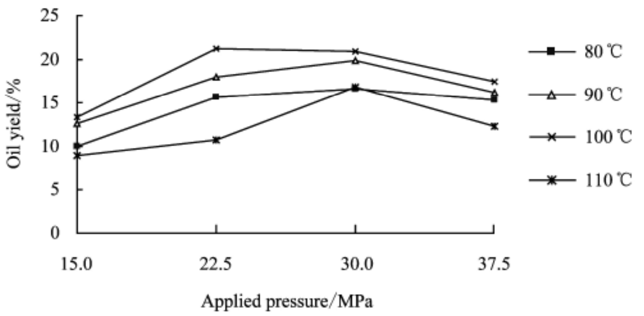

Figure 5 Effects of applied pressure on the percentage oil yield from finely ground Roselle seed heated at four levels of temperature for 30 min and expressed for 40 min

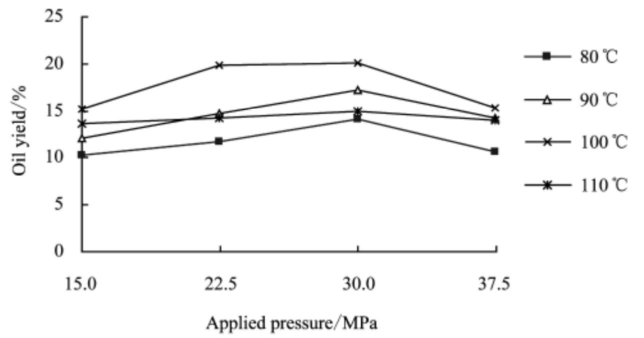

Figure 6 Effects of applied pressure on the percentage oil yield from coarselyground Roselle seed heated for 30 min. and expressed for 40 min

Generally there was an increase in the oil yield as the heating temperature is increased as it caused the protein to coagulate at a very fast rate thus reducing the viscosity significantly and adjusting the moisture content thereby leading to the release of the oil bound to them. Oil flow was found to be inversely proportional to the kinematic viscosity which decreases with increase in heating temperature thus increase in the ability of the oil to flow[19].

As the moisture content increases, the oil yield increased generally at 15 and 22.5 MPa for both particle sizes as shown in Figures 7 and 8. At higher pressures and higher levels of moisture the oil yield either remain unchanged or decreased as the moisture content increases beyond 6.4%. This could be attributed to the fact that moisture addition assist in reaching the saturation point of the particles sooner during oil expression. This leads to the release of oil resulting from the deformation of oil cells when after initial compression, the entrapped air is pushed out and the liquid present in optimum quantity exerts the pressure in all directions. With increased compression the oil drains out from the system and the load is slowly transferred to the rigid structure of the solid cake thus leading to the inability of the entrapped oil within the cake matrix to be expressed due to the formation of a solid skeleton by the particles which prevent the load from being transferred to the oil. When there is excess moisture the liquid phase bears the entire load itself being incompressible and does not exert any pressure on the oil bearing particles causing an adverse effect on the oil yield[10].

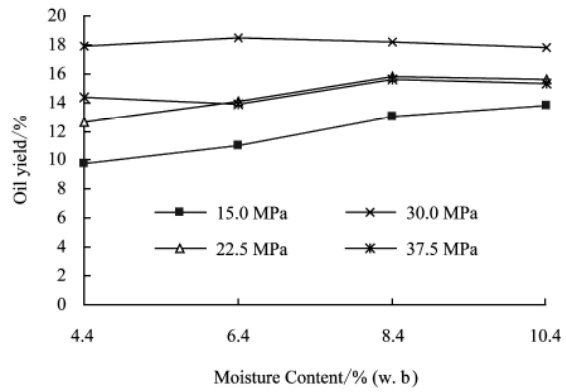

Figure 7 Effects of moisture content on oil yield at the various levels of applied pressure

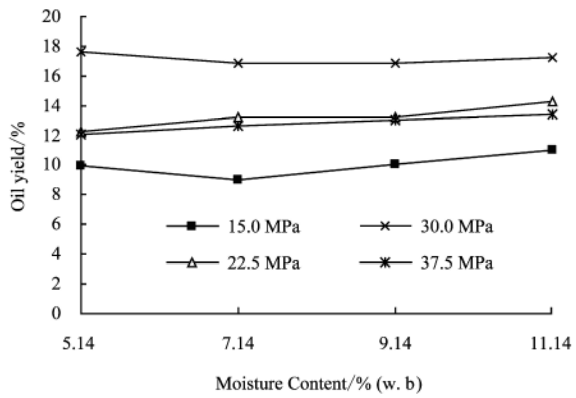

Figure 8 Effects of moisture content on oil yield from coarsely ground Roselle seeds at different levels of applied pressure

4 Conclusions

Processing parameters and size of the material used were found to affect the yield of oil from Roselle seeds. Oil yield increases with an increase in the processing parameters of pressure up to 30 MPa, temperature of 100℃ and decreased beyond these points. Oil yield increased with an increase in moisture content. Finely ground samples were found to have a higher yield than coarsely ground samples at the different processing parameters.

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