Machine and Seed Factors affecting Oil Recovery in Ram Presses

Kamau, J. M.[1] and Some, D. K.[2]
[1]Egerton University, P. O. Box 536, Egerton, Kenya
[2]Moi University, P. O. Box 3900, Eldoret, Kenya

Abstract

The ram press is a manual device used to extract oil from oilseeds such as sunflower, sesame, groundnut and rapeseed. Seed and machine factors affect the efficiency of oil extraction. The influence of sunflower seed moisture content and percent foreign materials, size of choke opening and length of rest period at end of the stroke on oil recovery with the ram press was determined. Values of factors giving highest extraction efficiencies were moisture content of 5.62% (71.67%), 0% foreign materials (267.5%), 4 seconds rest period (67.88%) and a choke opening of 1.28 cm (68.42%). Oil recovery at different levels of these factors was significantly different at the 95% level. There was no significant difference in oil recovery at moisture contents between 4.29 and 9.11%. The percent foreign materials in the seed should not exceed 5% if a significant reduction in oil recovery is to be avoided. Oil recovery at 4 and 6 second-rest periods was significantly higher than at the other rest periods. At a choke opening of 1.28 cm oil recovery was significantly higher than at other choke openings.

Key words: ram press, oil recovery, moisture content, applied pressure

Introduction

The ram press is a hand-operated machine suited for on-farm processing of a variety of oilseeds including sunflower, sesame, groundnut and rapeseed. The performance of the ram press is reported in terms of oil recovery in g per kg of seed or in extraction efficiency (EE) (Kamau, 1992). On-farm processing adds value to the oilseed crop and this has made the ram press a popular technology in the rural areas. Additionally, farmers are able to make direct use of the oilseed crop in terms of cooking oil and the protein cake for animal feeding (Kinaga, 1997; Kamau, 1996). However, the adoption rate of the technology is likely to be affected by low extraction efficiencies caused by factors other than the capability of the ram press. These factors can be grouped into seed factors and machine factors. The effect of some seed factors was reported by Kamau (2002), however, the settings of machine

factors at, which the processing was undertaken was not specified. The influence of these factors needs to be quantified so that farmers may use the information to increase oil recovery of their ram presses.

Sunflower seed is the most commonly processed seed possibly because its cultivation was more wide-spread even before the introduction of the ram press (Kinaga, 1997). However, information in literature on the influence of factors during processing covers mainly other types of machines and oilseeds. Bonginwar *et al*. (1977) and Owende (1990) reported a peak oil yield from groundnuts, using an expeller, at moisture content (MC) of 6% on the wet basis (wb). Pominski *et al* (1970) also identified an MC around 6% as being ideal for processing groundnut for oil. Pominski *et al*. (1970) showed that the amount of oil expressed from groundnut, in a plate press, tended to level off after 3 minutes of pressing at a pressure of 13.8 MPa. Adeiko and Ajibola (1989) working with a hydraulic press reported that oil yield increased with an increase in pressure up to a certain level beyond which it decreased. The influence of individual machine and seed factors on oil recovery at known levels of the other factors has not been determined for the ram press. Therefore, this study was carried to determine the effect of sunflower seed moisture content and percent foreign materials, the size of choke opening and length of the rest period at the end of the stroke, on oil recovery in ram presses.

Materials and Methods

Five bags of newly harvested hybrid sunflower seed was obtained and used in the experiments. The oil content of the seed was determined by the Soxhlet method using petroleum ether (Paquot and Hautfenne, 1987). To determine the effect of seed moisture content (MC) on oil recovery, the seed was dried in the sun and 1 kg samples taken at intervals of 30 minutes and oil extracted. At the same time, samples for MC determination were taken and dried in an air oven set at 103^{o}C for 2½ hours (American Society of Agricultural Engineers (ASAE) Yearbook of Standards, 1998). During subsequent experiments, the seed used was maintained at an MC of about 5.62%. The level of each factor at which experiments with the other factors were carried out had been determined during preliminary trials. One kg of seed in triplicate was processed at each level of the factor and the mass of oil recovered recorded.

To determine the effect of foreign materials, a sample of the seed was first cleaned thoroughly to remove all foreign materials. A set of sieves and a Ro-Tap shaker machine were used for cleaning. The sample of seed was placed on the top sieve and the machine ran for five minutes. Any foreign materials

remaining with the seed were picked by hand. Afterwards, the foreign materials in measured quantities were mixed with samples of clean seed to obtain percent foreign materials in the seed of 0, 2, 5, 7, 9 and 10%. These values covered a range above and below what is likely to be encountered in the field. The foreign material in these seeds was a mixture of dust, stones, immature seed, chaff and other organic and mineral matter. The seed and foreign materials were mixed thoroughly to ensure a homogeneous sample then oil recovery tests were carried out. Seed used in other experiments was from the cleaned sample with no foreign materials.

During experiments to determine the effect of the length of the rest period at the end of the stroke on oil recovery, the ram press was first brought to steady operation before data recording commenced. The rest period was the time the operator maintained pressure on the handle at the end of the stroke and therefore, the pressure on the seeds. Six rest periods of 0, 2, 4, 6, 8 and 10 seconds were used. The rest period used during experiments with other factors was 4-6 seconds.

The size of the choke opening or outlet for the cake was used to vary the pressure applied on the seeds during oil extraction. The sizes of choke openings were selected arbitrarily, starting at the smallest opening below which operation of the ram press was not possible. The choke openings were set and the size measured with a Vernier calliper. The choke openings used in the experiments were 1.18, 1.23, 1.28, 1.3, 1.33 and 1.38 cm. Preliminary experiments had showed that a previous setting had some influence on the subsequent one in terms of oil recovery. In order to exclude this influence in the results, the cage was emptied after each setting and the process of priming the cage started all over again. The ram press was brought to steady operation followed by data recording. The size of choke opening used with other experiments was 1.28 cm.

Analysis of variance was applied to the data of oil recoveries obtained at different levels of moisture content, percent foreign materials, length of rest period and size of choke opening. This was followed by the determination of the Least Significant Difference (LCD) among the mean values of OR at different levels the factors. The Least Squares method was used to fit lines to the data of OR for each of the factors. The analyses were expected to highlight the levels achieving the highest quantities of OR indicating a possible operating range for the ram press.

Results and Discussion

The oil content of the hybrid sunflower seed was 40.2%. Oil recovery from each trial was obtained in terms of g per kg of seed and converted to extraction efficiency (EE), which related the mass of oil obtained to the oil content. The variation of oil recovery (OR) with moisture content (MC) is shown in Table 1 and illustrated in Figure 1. Oil recovery rose from an EE of 0% at 14.04% MC to a peak of 71.67% at 5.62% MC then dropped to 48.85% at 3.65% MC. At 9.11% moisture contents and above, some kernel particles were forced through the cage bar openings and in addition, the cake discharged was clumped together and not loose. This made the operation of the ram press difficult and the choke had to be adjusted after every few strokes. At moisture contents below 4.29%, the seed cake was completely broken into small particles. At moisture contents above 7.88% the seed cake was not completely broken down with intact but flattened seeds being observed.

Oil recovery at different moisture contents was significantly different at the 95% significant level as shown in Table 1. A summary of the ANOVA table is shown in the Appendix. For moisture contents between 4.28 and 9.11%, the corresponding OR values were not significantly different as shown in Table 1. This implied that processing seeds at moisture contents below 4.28% and above 9.11% would result in oil recoveries that are significantly lower than those obtained at moisture contents within this range. A model that can be used to predict values of OR for different levels of moisture contents is shown in Figure 1.

The amount of foreign materials in the seed had a significant influence ($\alpha = 0.05$) on oil recovery. As percent foreign materials increased, the oil recovery decreased steadily from an EE of 66.53% at 0% to 10.57% at 10% as shown in Table 2 and illustrated in Figure 2. Oil recovery obtained at the 0 and 5% FM was significantly higher than at the other levels. This implied that percent foreign materials should not exceed 5% if a significant reduction in OR is to be avoided. A quadratic polynomial that can be used to predict OR values at different levels of percent foreign materials is shown in Figure 2. As the percent foreign materials increased, the ram press became more difficult to operate and the quantity of seed particles in the oil increased.

Table 1: Mean values of oil recovery at different levels of seed moisture content

	Moisture content (MC), percent wet basis (WB)										
MC	3.65	4.28	4.9	5.23	5.62	6.09	7.88	9.11	11.57	12.2	14
OR	196.4	245.6	267	277.8	288.1	278.7	270.8	237.6	80.2	13.2	0
EE	48.85	61.09	66.4	69.11	71.67	69.34	67.37	59.09	19.96	3.28	0
LSD	5.12										

Table 2: Variation of OR with percent foreign materials in the seed

	Percent foreign materials (FM)						
FM	0	5	6	7	8	9	10
OR	267.5	259.5	204.9	171.05	125.02	52.5	42.5
EE	66.53	64.55	50.97	42.55	31.1	13.06	10.57
LSD	45.77						

Oil recovery was influenced significantly ($\alpha = 0.05$) by the length of the rest period at the end of the stroke as shown in Table 3 and illustrated in Figure 3. Oil recovery was highest at a rest period of 4 seconds with reduced quantities at lower and higher rest periods. The oil recovery at 4 and 6 seconds was not significantly different as shown in Table 3. Given that OR values were highest at these periods pointed to a possible operating range for the ram press. At the zero second rest period, there was suck-back of oil as the piston was withdrawn for the next stroke and this may have contributed to the low values of oil recovery (OR) at this level. The lower OR at rest periods above 6 seconds may have been caused by failure to achieve a critical mass of oil necessary for flow during consecutive strokes. A useful model that can be used to calculate OR values at different levels of rest period is shown in Figure 3. The length of the rest period was taken to represent speed of operation in terms of number of strokes per minute. Speed of operation of the ram press is important since it is a manual and strenuous work that must be carried out over a long period of time.

Table 3: Variation of oil recovery with rest period

	Rest period (RP) in seconds					
RP	0	2	4	6	8	10
OR	233.4	243.5	272.9	269.2	257.4	245.8
EE	58.03	60.57	67.88	66.96	64.02	61.14
LSD	7.6					

The average oil recoveries at different choke openings are shown Table 4 and illustrated in Figure 4. The lowest EE was 28.13%, which was obtained at the largest choke opening of 1.38 cm. The EE peaked to 68.42% at a choke opening of 1.28 cm then decreased to 40.62% at a choke opening of 1.33 cm. Oil recoveries obtained at different choke openings were significantly different at the 95% level. As shown in Table 4, the OR obtained at 1.23 cm and 1.3 cm choke openings were not significantly different. The two values are the immediate values above and below the choke opening of 1.28 cm, which had the highest value of OR. The Least Squares model for this data is shown in Figure 4.

Table 4: Variation of oil recovery with size of choke opening

	Choke opening (CO) in cm					
CO	1.18	1.23	1.28	1.3	1.33	1.38
OR, g	176.4	240.8	275.03	248	163.3	113.1
EE, %	43.88	59.91	68.42	61.7	40.62	28.13
LSD	5.32					

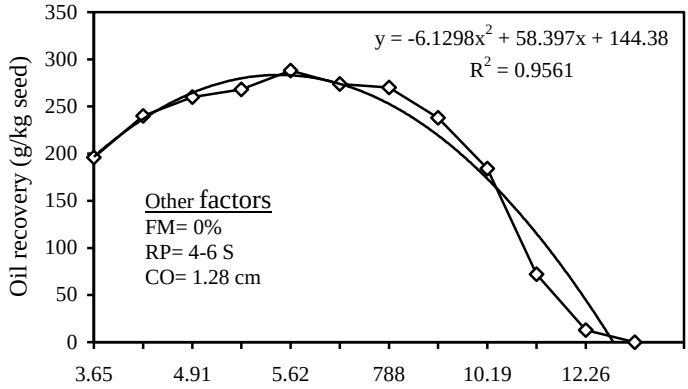

Figure 1: Variation of oil recovery with moisture content of the seed

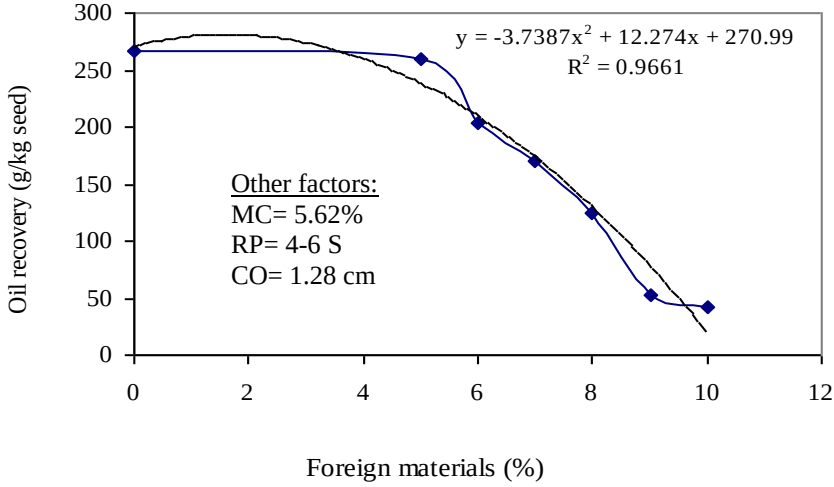

Figure 2: Variation of OR with percent foreign material

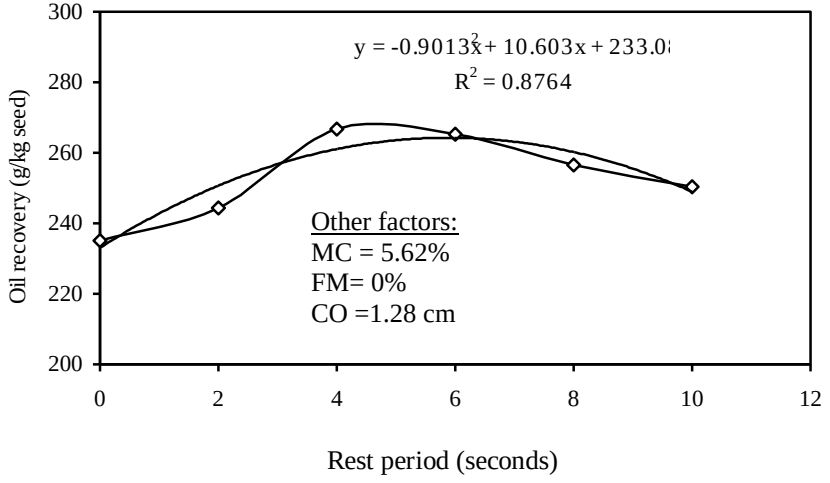

Figure 3: Variation of oil recovery with rest period at the end of stroke

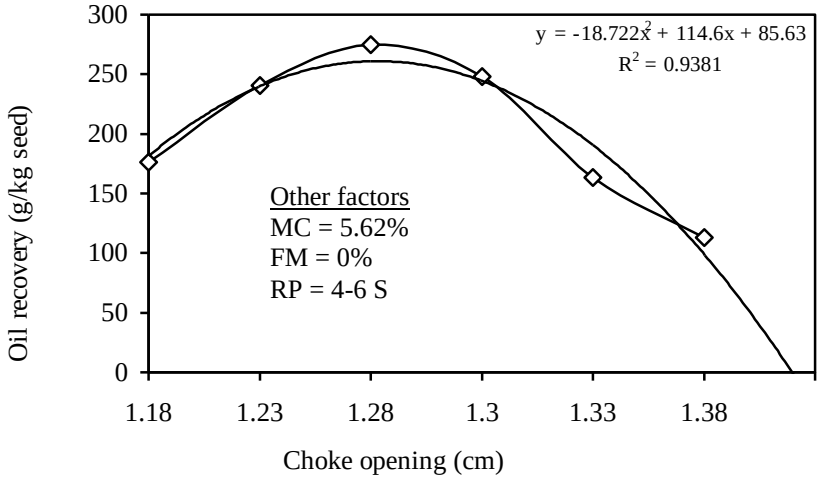

Figure 4: Variation of oil recovery with choke opening

Conclusions and Recommendations

Oil recovery achieved by the ram press is influenced by the seed moisture content and quantity of foreign materials and also by the size of the choke opening and the length of the rest period at the end of the stroke. Values of factors giving significantly higher oil recovery were a moisture content of 5.62%, 0% foreign materials, 4 seconds rest period and a choke opening of 1.28 cm. These conditions should be maintained during ram press operation in order to maximise oil recovery when processing sunflower seed.

References

Adeiko, K. A. and O. O. Ajibola. (1989). Processing factors affecting yield and quality of mechanically expressed groundnut oil.

American Society of Agricultural Engineers (ASAE). (1998). Yearbook of Standards. ASAE, St. Joseph, Michigan.

Bonginwar, D. R., S. R. Padwal-Desai and A. Smenivasam. (1977). A study on defatting of peanuts and soybeans for developing ready-to-eat snacks. Indian Packer. May-June: 61-75.

Kamau, J. M. (1992). Effect of sunflower seed pre-treatment on oil extraction with the ram press. Paper presented at the Kenya Society of Agricultural Engineers Annual Meeting, held at JKUCAT from 5th to 7th August 1992.

Kamau, J. M. (1996). Oilseed Processing (K) Project. Final project report. Egerton University, Njoro.

Kamau, J. M. (2002). Optimization of factors affecting mechanical oil extraction in ram presses. Unpublished Ph.D. thesis. Moi University, Eldoret, Kenya.

Kinaga, J. W. (1997). Rural/Oil Production and Processing Project (ROPPP). Poceedings of the workshop on future strategies for the oilseed subsector in Kenya. 8-19th Oct. 1995. Ministry of Agriculture, Livestock Development and Marketing. Nairobi, Kenya.

Owende, J. J. (1990). Evaluation of screw oilseed press. Unpublished M.Sc. Thesis. Silsoe College.

Paquot, C. and A. Hautfenne. (1987). Standard methods for the analysis of oils, fats and their derivatives. 7th ed. Blackwell Sc. Publications, Oxford, UK.

Pominski, J., H. M. Pearce and J. J. Spadaro. (1970). Partially defatted peanuts, factors influencing oil removal by pressing. J. Food Technol. 24(6):92-95.

Appendix

Table A1: Summary of ANOVA tables for the analyses of oil recovery at different levels of moisture content, percent foreign materials, length of rest period and choke opening

Oil recovery for moisture content						
Source of variation	df	SS	MS	F	P-value	F crit
Between groups	11	366447.8	33313.44	903.2	1.3E-28	2.22
Within groups	24	885.2277	36.88449			
Total	35	367333				
Oil recovery for foreign material						
Source of variation	df	SS	MS	F	P-value	F crit
Between groups	6	150517.7	25086.28	670.6	2.16E-16	2.85
Within groups	14	523.7149	37.40820			
Total	20	151041.4				
Oil recovery for rest period						
Source of variation	df	SS	MS	F	P-value	F crit
Between groups	5	3599.460	719.8919	19.8	2.03E-05	3.1
Within groups	12	436.7729	36.39774			
Total	17	4036.232				
Oil recovery for choke opening						
Source of variation	df	SS	MS	F	P-value	F crit
Between groups	5	57038.82	11407.76	637.5	4.06E-14	3.1
Within groups	12	214.7205	17.89338			
Total	17	57253.54				