CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Czech University of Life Sciences Prague

Faculty of Engineering

Department of Mechanical Engineering

MASTER'S THESIS

Meseret Abraham Afework

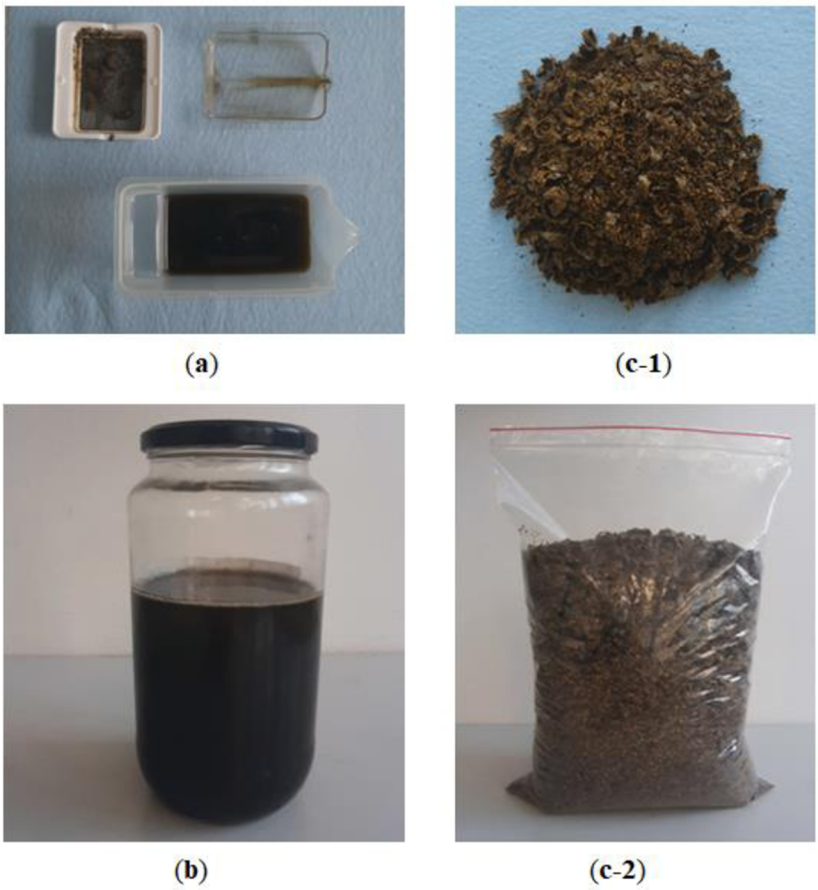
Analyses of oil output indicators of selected bulk oilseeds under linear and non-linear compression processes

Supervisor

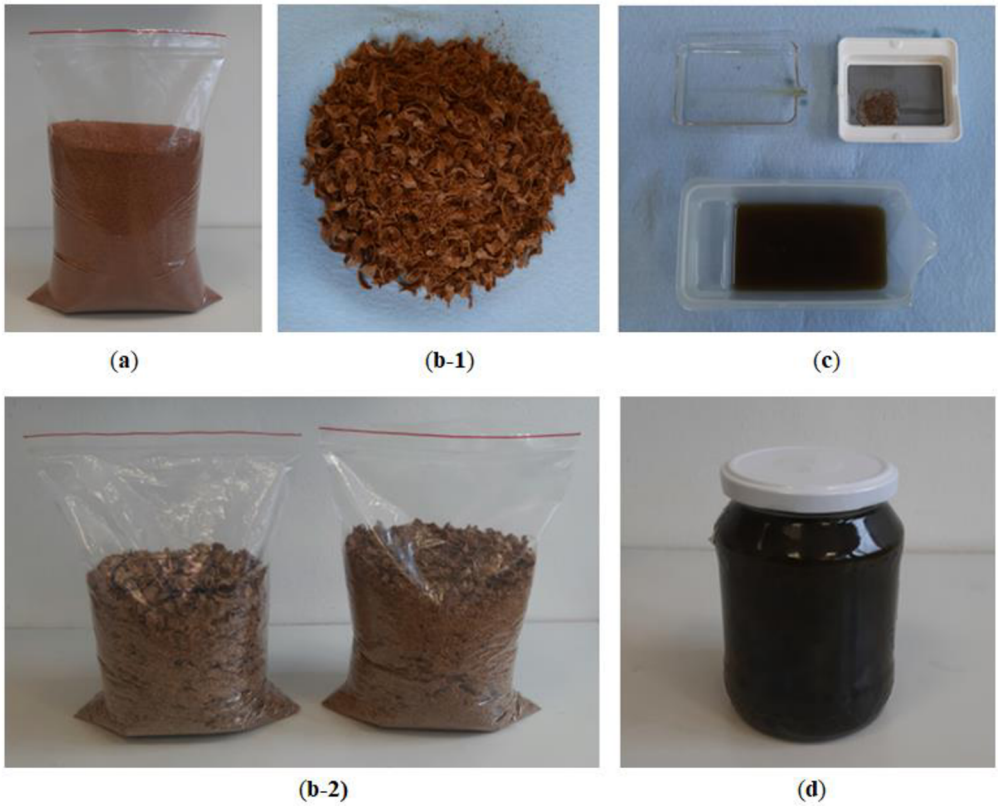
doc.Ing. Abraham Kabutey, Ph.D.

2025

APPENDIXES



Appendix 1. Oil extraction process of (a) rapeseeds, (b) extracted rapeseed oil and (c-1) and (c-2) rapeseed press cake.



Appendix 2. Oil extraction process of (a) camelina seeds, (b-1 and b-2) pressed cake, (c) press components and (d) extracted camelina oil.

Appendix 3. Preliminary experiment of rapeseed oil extraction under mini-screw pressing.

Sample weight (g)	**Seedcake (g)**	**Mass of oil (g)**	**Oil yield (%)**	**Pressing time (min)**	**Throughput (g/min)**	**Throughput (kg/hr)**
50	41.39	7.27	14.54	2.5	20.0	1.20
100	71.28	23.10	23.10	3	33.3	2.00
150	108.22	35.93	23.95	4	37.5	2.25
200	145.27	50.41	25.21	5	40.0	2.40
250	182.25	62.13	24.85	7	35.7	2.14
300	218.31	77.21	25.74	8	37.5	2.25
350	256.32	86.19	24.63	9	38.9	2.33
400	293.39	101.17	25.29	10	40.0	2.40
450	330.77	111.42	24.76	12	37.5	2.25

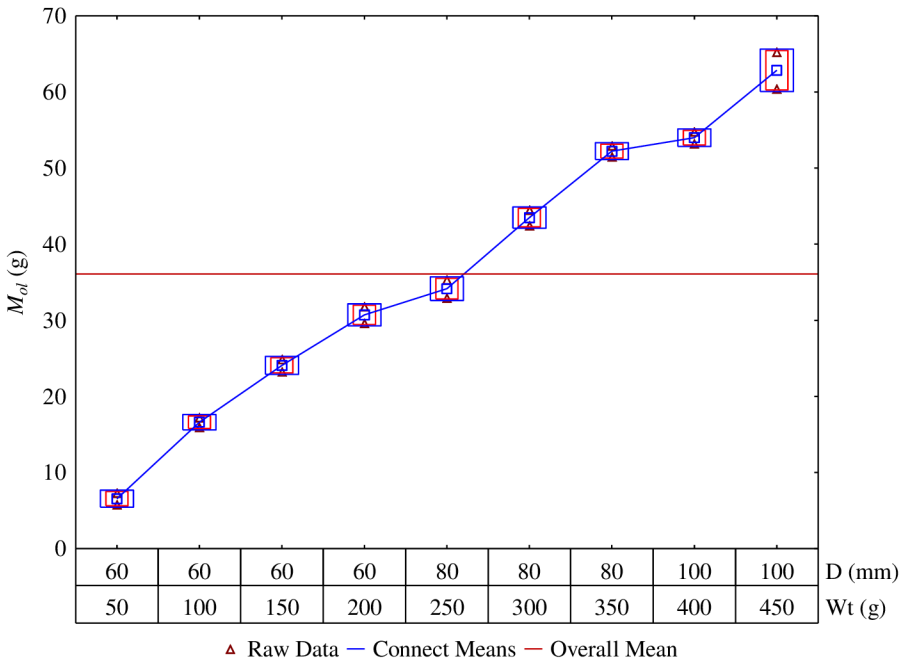
Appendix 4. Preliminary experiment of camelina seed oil extraction under mini-screw pressing.

Sample weight (g)	**Seedcake (g)**	**Mass of oil (g)**	**Oil yield (%)**	**Pressing time (min)**	**Throughput (g/min)**	**Throughput (kg/hr)**
50	40.31	8.88	17.76	3	16.70	1.00
100	76.69	22.55	22.55	4	25.00	1.50
150	111.44	36.4	24.27	5	30.00	1.80
200	147.89	50.09	25.05	6	33.30	2.00
250	183.52	64.18	25.67	8	31.30	1.88
300	220.89	74.07	24.69	8	37.50	2.25
350	256.45	89.29	25.51	10	35.00	2.10
400	294.85	101.95	25.49	12	33.30	2.00
450	332.15	112.22	24.94	11	40.90	2.45

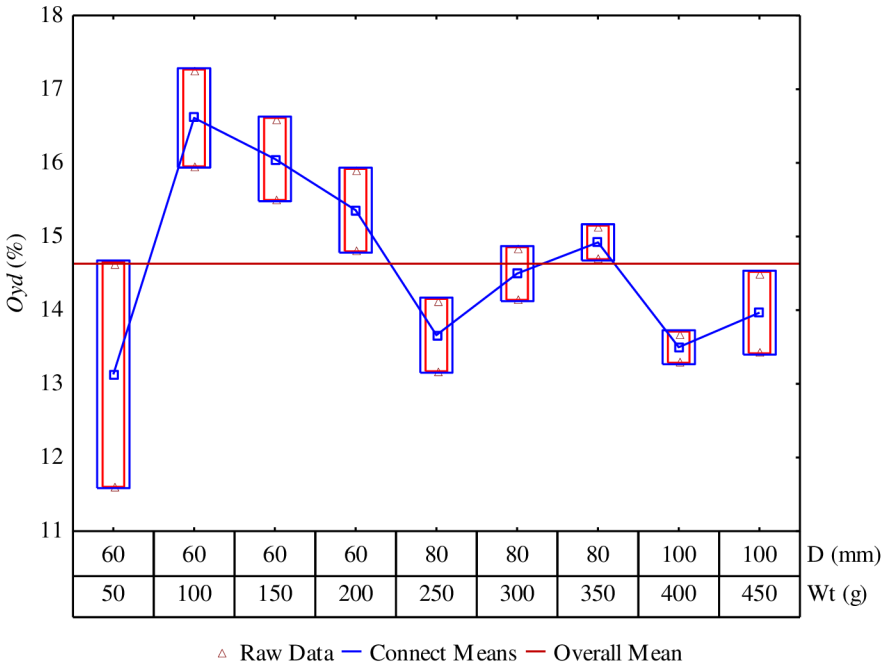
Appendix 5. Total sample weight and losses of rape and camelina seeds under mini-screw pressing.

Sample weight (g)	**Rapeseeds**		**Camelina seeds**	
	* Total sample weight (g)	* Losses (g)	* Total sample weight (g)	* Losses (g)
50	48.66	1.34	49.19	0.81
100	94.38	5.62	99.24	0.76
150	144.15	5.85	147.84	2.16
200	195.68	4.32	197.98	2.02
250	244.38	5.62	247.70	2.30
300	295.52	4.48	294.96	5.04
350	342.51	7.49	345.74	4.26
400	394.56	5.44	396.8	3.20
450	442.19	7.81	444.37	5.63

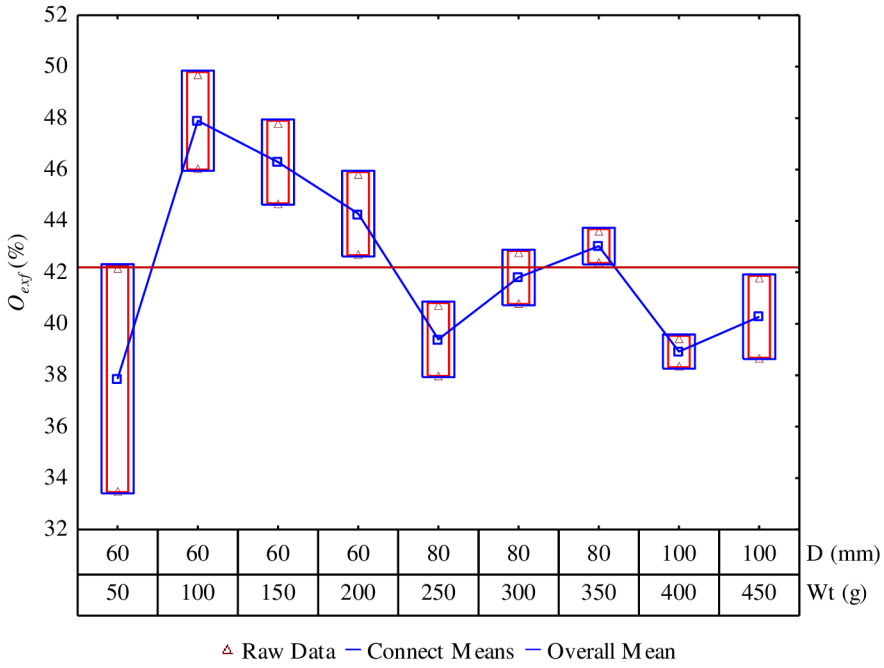
* Extracted crude oil and seedcake



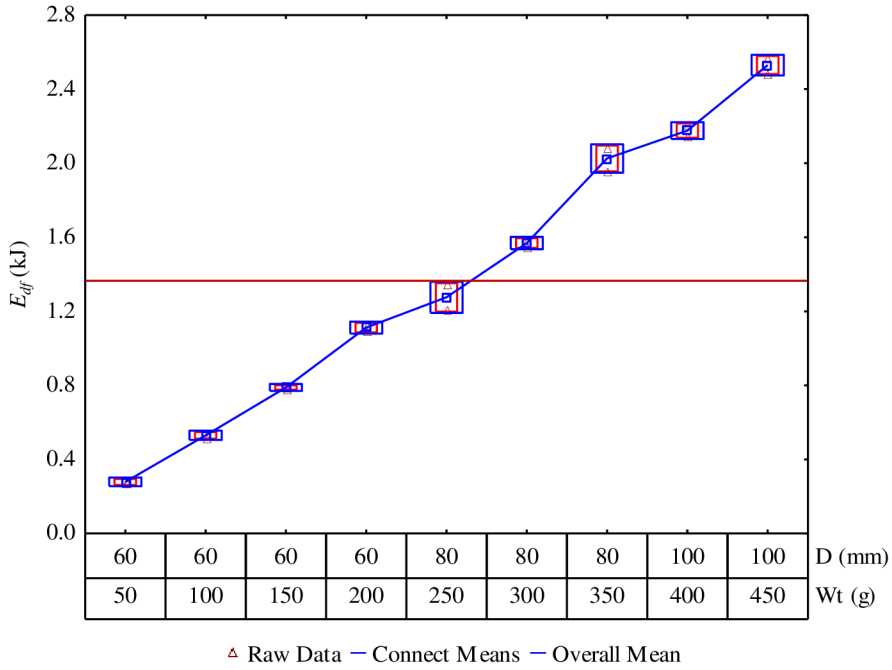
Appendix 6. Mass of oil, M_{ol} of bulk rapeseeds under linear pressing with sample weight (Wt) and diameter of pressing vessel (D).



Appendix 7. Oil yield O_{yd} of bulk rapeseeds under linear pressing with sample weight (Wt) and diameter of pressing vessel (D).



Appendix 8. Oil expression efficiency O_{exf} of bulk rapeseeds under linear pressing with sample weight (Wt) and diameter of pressing vessel (D).



Appendix 9. Deformation energy E_{df} of bulk rapeseeds under linear pressing with sample weight (Wt) and diameter of pressing vessel (D).

Appendix 10. Calculation of throughput of bulk rapeseeds under linear and non-linear pressing operations.

Initial sample weight(g)*	Pressing time (s)*	Throughput (kg/h) *	Seedcake (g)**	Pressing time (min)**	Throughput (kg/h) **
50	147.36	1.22	42.68	2	1.28
50	162.72	1.11	44.19	4	0.66
100	334.02	1.08	82.75	4	1.24
100	330.94	1.09	84.03	5	1.01
150	497.22	1.09	125.11	5	1.50
150	492.58	1.10	126.73	6	1.27
200	661.42	1.09	168.2	6	1.68
200	672.40	1.07	170.37	8	1.28
250	459.22	1.96	217.03	7	1.86
250	468.46	1.92	214.66	7	1.84
300	553.44	1.95	257.53	9	1.72
300	558.36	1.93	255.49	9	1.70
350	642.96	1.96	297.04	11	1.62
350	664.72	1.90	298.52	11	1.63
400	479.42	3.00	346.79	12	1.73
400	488.74	2.95	345.23	12	1.73
450	545.40	2.97	384.74	13	1.78
450	548.52	2.95	389.56	14	1.67

* Under linear pressing ** Under non-linear pressing

Appendix 11. Determination of residual oil in the seedcake of bulk rapeseeds.

Initial sample weight (g)*	Seedcake sample weight (g)**	Residual mass of oil (g)	Residual oil yield (%)	Residual oil expression efficiency (%)
50	42.68	4.60	10.78	26.07
50	44.19	8.24	18.65	45.09
100	82.75	13.92	16.82	40.68
100	84.03	16.92	20.14	48.70
150	125.11	22.63	18.09	43.74
150	126.73	24.62	19.43	46.98
200	168.20	32.53	19.34	46.77
200	170.37	33.98	19.94	48.23
250	217.03	44.45	20.48	49.53
250	214.66	42.43	19.77	47.80
300	257.53	52.67	20.45	49.46
300	255.49	50.99	19.96	48.27
350	297.04	58.40	19.66	47.55
350	298.52	60.28	20.19	48.83
400	346.79	73.34	21.15	51.14
400	345.23	72.53	21.01	50.81
450	384.74	78.75	20.47	49.50
450	389.56	83.63	21.47	51.92

* Oil extraction under linear process; ** Oil extraction under non-linear process.

Appendix 12. Detailed analyses of the oil extraction of rapeseeds under non-linear pressing.

M_{ap} (g)	M_{sk} (g)	M_{ol} (g)	T_{ms} (g)	M_{df} (g)	M_{ls} (%)	O_{tm} (%)	C_m (%)
42.68	36.98	4.60	41.58	1.1	2.58	97.42	100
44.19	33.43	8.24	41.67	2.52	5.70	94.30	100
82.75	66.09	13.92	80.01	2.74	3.31	96.69	100
84.03	66.5	16.92	83.42	0.61	0.73	99.27	100
125.11	99.53	22.63	122.16	2.95	2.36	97.64	100
126.73	98.95	24.62	123.57	3.16	2.49	97.51	100
168.2	133.45	32.53	165.98	2.22	1.32	98.68	100
170.37	132.81	33.98	166.79	3.58	2.10	97.90	100
217.03	168.91	44.45	213.36	3.67	1.69	98.31	100
214.66	167.58	42.43	210.01	4.65	2.17	97.83	100
257.53	201.16	52.67	253.83	3.7	1.44	98.56	100
255.49	200.28	50.99	251.27	4.22	1.65	98.35	100
297.04	233.54	58.40	291.94	5.1	1.72	98.28	100
298.52	233.27	60.28	293.55	4.97	1.66	98.34	100
346.79	267.16	73.34	340.5	6.29	1.81	98.19	100
345.23	266.59	72.53	339.12	6.11	1.77	98.23	100
384.74	298.61	78.75	377.36	7.38	1.92	98.08	100
389.56	299.67	83.63	383.3	6.26	1.61	98.39	100

M_{ap}: Mass of sample after linear pressing

M_{sk}: Mass of seedcake after non-linear pressing

M_{ol}: Mass of oil after non-linear pressing

T_{ms}: Total mass of sample ($M_{sk} + M_{ol}$)

M_{df}: ($T_{ms} - M_{ap}$)

M_{ls}: Percentage materal losses (oil and seedcake)

O_{tm}: Percentage material total (T_{ms}/M_{ap})*100

C_m: Total sample material ($O_{tm} + M_{ls}$)

Appendix 13. Determined total amounts of mass of oil, oil yield and oil expression efficiency of rapeseeds under linear and non-linear pressing operations.

S_{wt} (g)	M_{ol} (g)*	M_{ol} (g)**	TM_{ol} (g)	TO_{yd} (%)	TO_{exf} (%)
50	7.32	4.60	11.92	23.84	68.75
50	5.81	8.24	14.05	28.10	81.03
100	17.25	13.92	31.17	31.17	89.88
100	15.97	16.92	32.89	32.89	94.84
150	24.89	22.63	47.52	31.68	91.35
150	23.27	24.62	47.89	31.93	92.06
200	31.8	32.53	64.33	32.17	92.75
200	29.63	33.98	63.61	31.81	91.71
250	32.97	44.45	77.42	30.97	89.30
250	35.34	42.43	77.77	31.11	89.70
300	42.47	52.67	95.14	31.71	91.45
300	44.51	50.99	95.50	31.83	91.80
350	52.96	58.40	111.36	31.82	91.75
350	51.48	60.28	111.76	31.93	92.08
400	53.21	73.34	126.55	31.64	91.23
400	54.77	72.53	127.30	31.83	91.77
450	65.26	78.75	144.01	32.00	92.28
450	60.44	83.63	144.07	32.02	92.32

S_{wt}: Initial sample weight

M_{ol} *: Mass of oil under linear pressing

M_{ol} **: Mass of oil under non-linear pressing

TM_{ol}: Total mass of oil (M_{ol}* + M_{ol} **)

TO_{yd}: Total oil yield (TM_{ol} / S_{wt})*100

TO_{exf}: Total oil expression efficiency (TO_{yd} / Seed oil content) * 100

Appendix 14. Descriptive statistics of maximum force of bulk rapeseeds under linear pressing.

Sample weight (g)	Maximum force (kN)				
	N	Mean	Std. Dev.	Std. Err.	% CV
50[a]	2	133.14	2.68	1.90	2.02
100[a]	2	146.08	2.86	2.02	1.96
150[a]	2	152.86	1.83	1.30	1.20
200[a]	2	165.21	1.19	0.84	0.72
250[b]	2	243.64	4.96	3.51	2.04
300[b]	2	260.97	4.17	2.95	1.60
350[b]	2	273.79	7.37	5.21	2.69
400[c]	2	423.98	2.81	1.99	0.66
450[c]	2	436.63	4.77	3.37	1.09

N: Number of sample; Std. Dev.: Standard Deviation; Std. Err.: Standard Error; CV: Coefficient of Variation; [a] Pressing vessel diameter 60 mm; [b] 80 mm and [c] 100 mm.

Appendix 15. Descriptive statistics of deformation of bulk rapeseeds under linear pressing.

Sample weight (g)	Deformation (mm)				
	N	Mean	Std. Dev.	Std. Err.	% CV
50[a]	2	12.90	0.91	0.64	7.02
100[a]	2	27.70	0.18	0.13	0.66
150[a]	2	41.25	0.28	0.20	0.67
200[a]	2	55.56	0.65	0.46	1.17
250[b]	2	38.64	0.52	0.36	1.34
300[b]	2	46.31	0.32	0.23	0.69
350[b]	2	54.49	1.28	0.91	2.35
400[c]	2	40.33	0.55	0.39	1.37
450[c]	2	45.57	0.19	0.14	0.42

N: Number of sample; Std. Dev.: Standard Deviation; Std. Err.: Standard Error; CV: Coefficient of Variation; [a] Pressing vessel diameter 60 mm; [b] 80 mm and [c] 100 mm.

Appendix 16. Descriptive statistics of hardness of bulk rapeseeds under linear pressing.

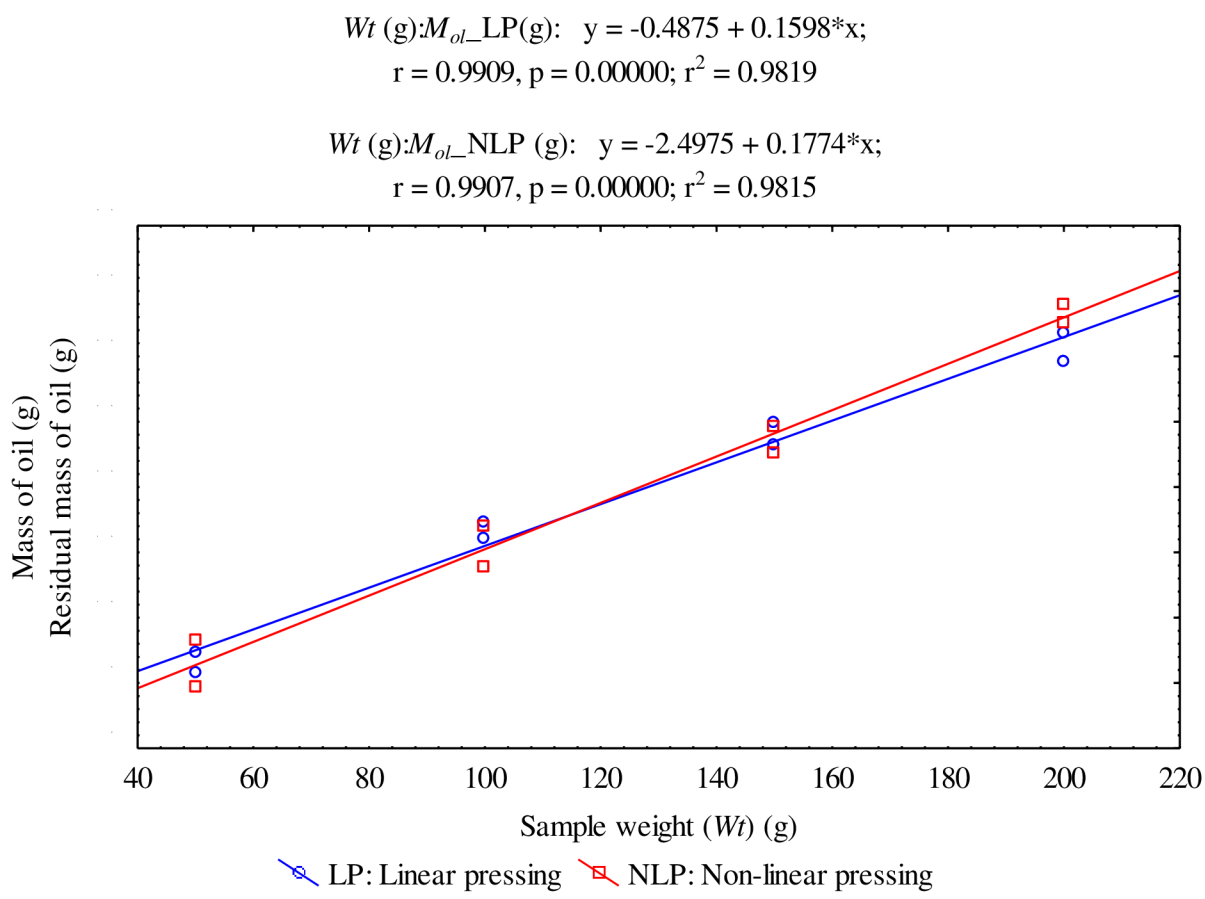
Sample weight (g)	Hardness (kN/mm)				
	N	Mean	Std. Dev.	Std. Err.	% CV
50[a]	2	10.34	0.52	0.37	5.00
100[a]	2	5.27	0.07	0.05	1.30
150[a]	2	3.71	0.07	0.05	1.87
200[a]	2	2.97	0.01	0.01	0.45
250[b]	2	6.31	0.04	0.03	0.70
300[b]	2	5.64	0.13	0.09	2.29
350[b]	2	5.03	0.25	0.18	5.04
400[c]	2	10.51	0.21	0.15	2.03
450[c]	2	9.58	0.14	0.10	1.51

N: Number of sample; Std. Dev.: Standard Deviation; Std. Err.: Standard Error; CV: Coefficient of Variation; [a] Pressing vessel diameter 60 mm; [b] 80 mm and [c] 100 mm.

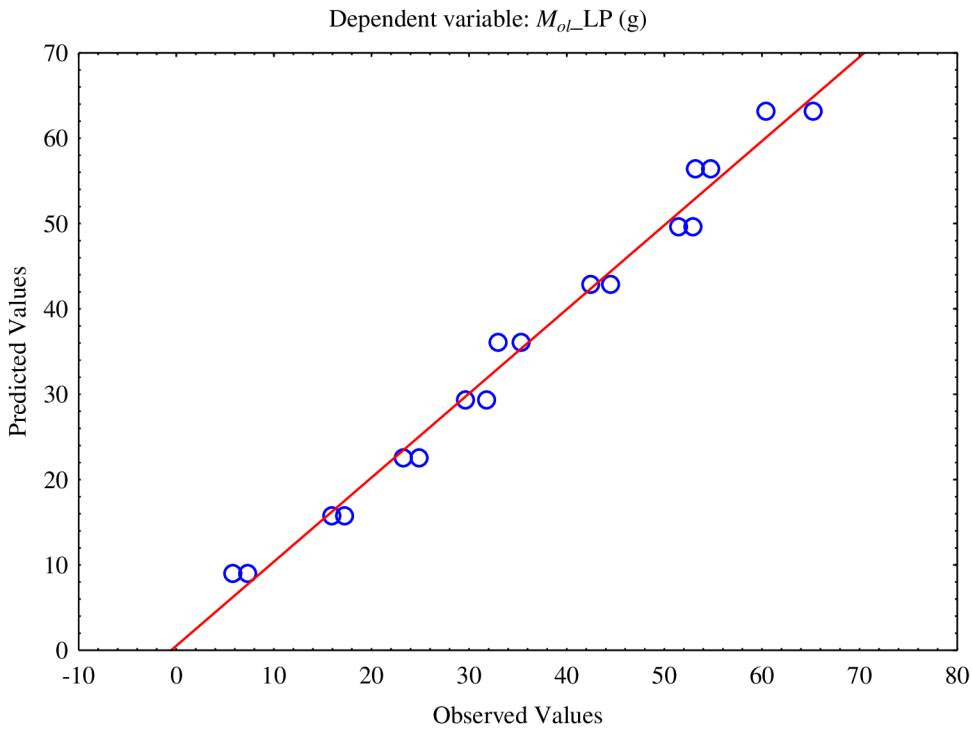
Appendix 17. Descriptive statistics of compressive stress of bulk rapeseeds under linear pressing.

Sample weight (g)	Compressive stress (MPa)				
	N	Mean	Std. Dev.	Std. Err.	% CV
50[a]	2	47.09	0.95	0.67	2.02
100[a]	2	51.66	1.01	0.72	1.96
150[a]	2	54.06	0.65	0.46	1.20
200[a]	2	58.43	0.42	0.30	0.72
250[b]	2	48.47	0.99	0.70	2.04
300[b]	2	51.92	0.83	0.59	1.60
350[b]	2	54.47	1.47	1.04	2.69
400[c]	2	53.98	0.36	0.25	0.66
450[c]	2	55.59	0.61	0.43	1.09

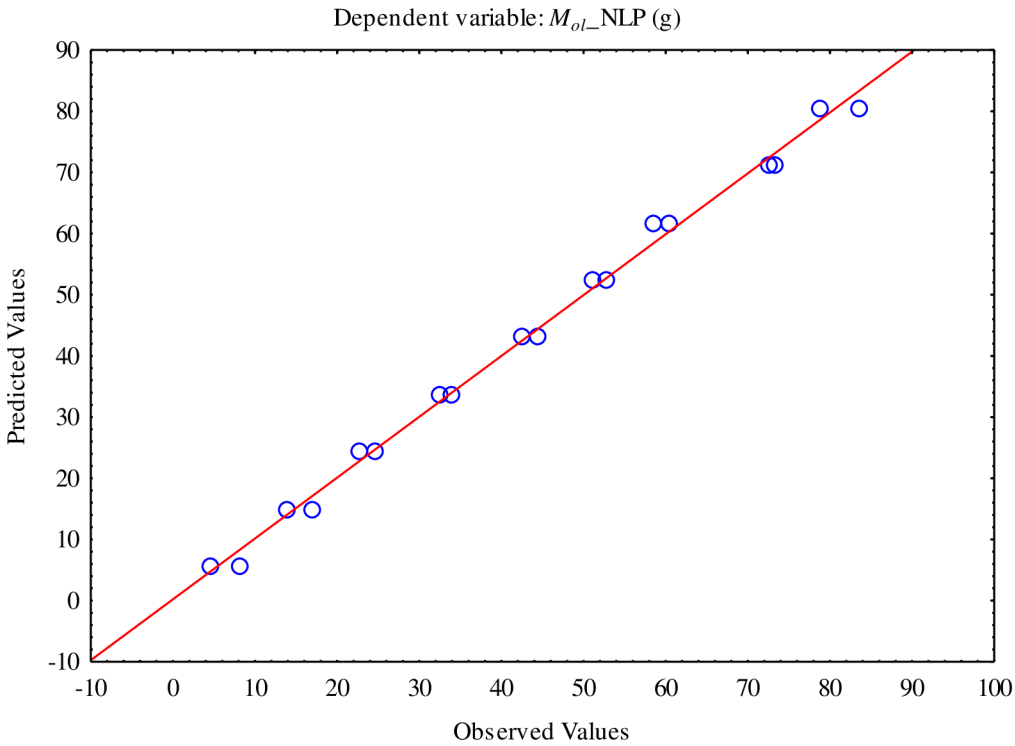
N: Number of sample; Std. Dev.: Standard Deviation; Std. Err.: Standard Error; CV: Coefficient of Variation; [a] Pressing vessel diameter 60 mm; [b] 80 mm and [c] 100 mm.



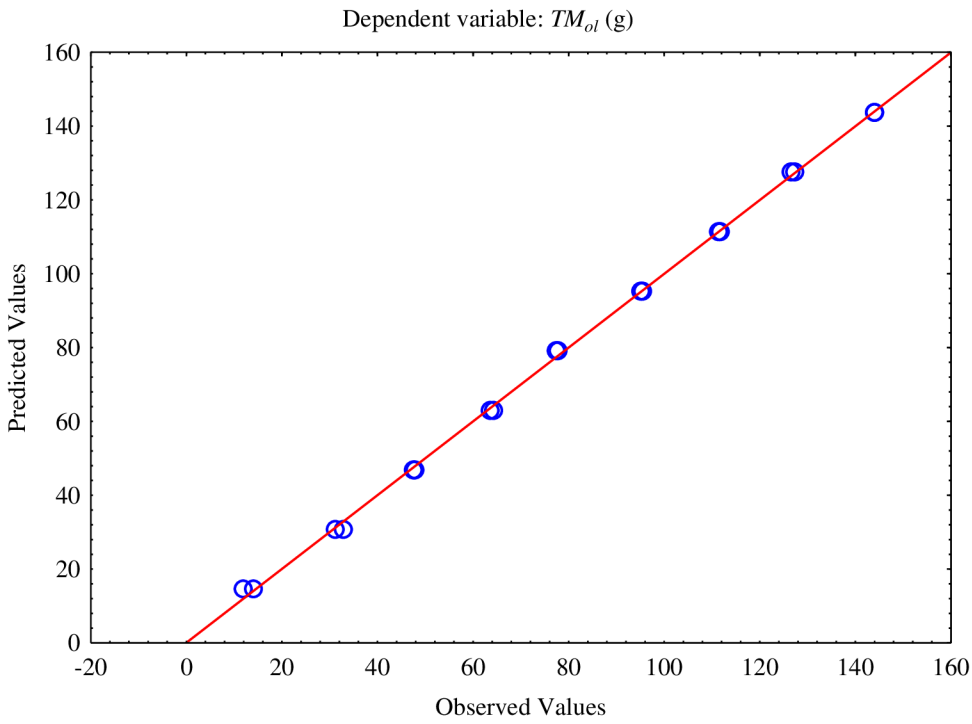
Appendix 18. Scatterplot of mass of oil and residual mass of oil with sample weight under linear and non-linear pressing operations.



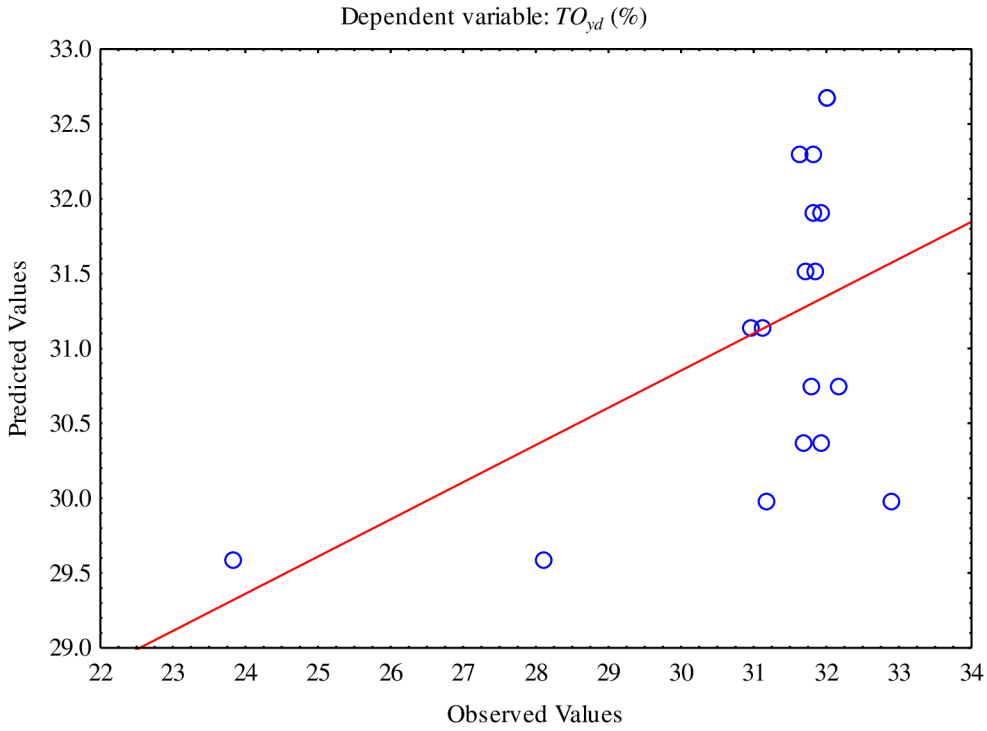
Appendix 19. Predicted and observed values of mass of oil under linear pressing (LP).



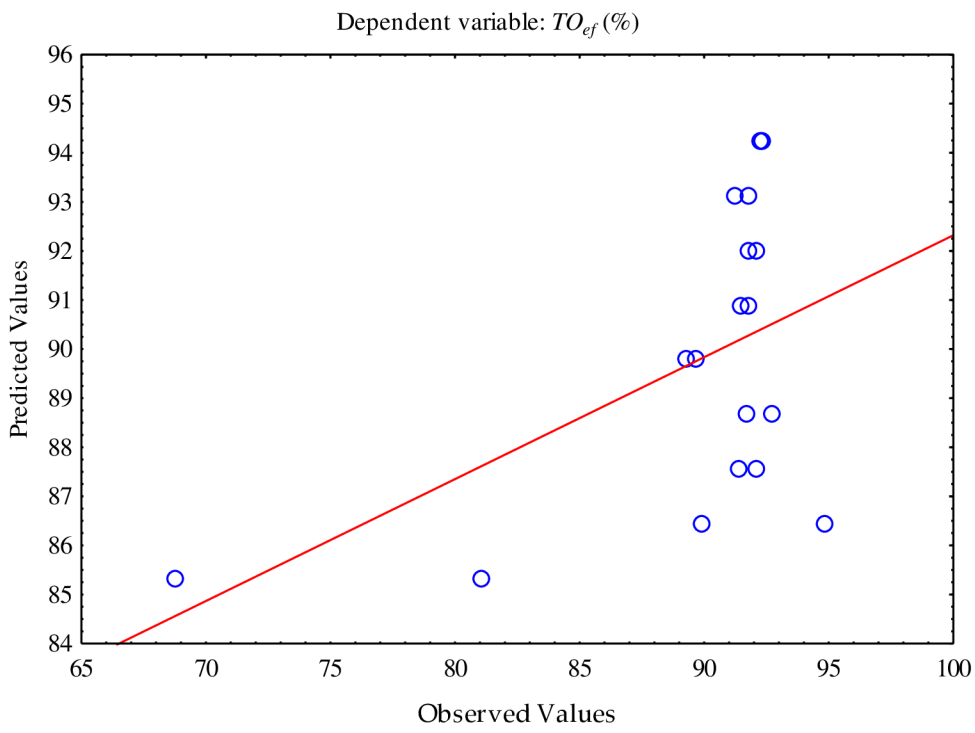
Appendix 20. Predicted and observed values of mass of oil under nonlinear pressing (NLP).



Appendix 21. Predicted and observed values of total mass of oil under LP and NLP.



Appendix 22. Predicted and observed values of total oil yield under LP and NLP.



Appendix 23. Predicted and observed values of total oil expression efficiency under LP and NLP.