ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1995 z. 427, 127-135

EVALUATION OF TECHNOLOGICAL QUALITY OF RAPESEEDS DRIED IN INDUSTRIAL DRIERS*

J. Sadowska[1], *J. Fornal*[1], *A. Ostaszyk*[1], *T. Winnicki*[2]

[1]Institute of Animal Reproduction and Food Research, Polish Academy of Sciences, Tuwima 10, 10-718 Olsztyn, Poland
[2]Oil Plant 'OLVIT', Wiślana 19, 80-555 Gdańsk, Poland

A b s t r a c t. Greater susceptibility of rapeseeds to crushing and reduced oil recovery during extraction might result from unproper post-harvest drying. The effect of drying in selected types of industrial driers on seed processability was studied. Indices for the estimation of seed processability, i.e., P_{or}/P_{od} and τ_d/τ_r ratios, which consider the variety differences, are proposed. The quality of dried seeds varied depending on the type of drier and the drying parameter restrictions.

K e y w o r d s: bulk rapeseeds, industrial drying, mechanical properties, rapeseed oil, seed processability

INTRODUCTION

In Poland industrial drum driers SB 1.5 used for drying green fodders are also often used for drying of rapeseeds. It is commonly recognized that rapeseeds dried in this type of driers are subjected to:

- serious mechanical damage, due to the transvasing of seeds during drying;
- the effect of high temperature, evoked by the unexpected fluctuation of air temperature at the drum inlet;
- the limited control of air flow, and temperature to dried material.

The intensity of these negative processess is closely related to the initial seed water content. In order to obtain the appropriate, final water content from highly moist seeds, it is necessary to prolong drying time, or increase drying temperature, which involves even more severe mechanical and thermal damages. Rapeseed of extremely low percolation during extraction occurred often in the 80-ties, thereby the examination of reasons seemed to be advisable. Fornal *et al.* [1,2] examined the physical properties of such seeds and found that a low percolation had resulted from the inappropriate post-harvest drying of seeds. It lowered the seeds mechanical resistance and caused the powdering of press cakes. Seeds of lower processability come mainly from the facilities equipped with drum driers. The above information suggested industrial research into the drum driers commonly used in the North of Poland.

LIST OF SYMBOLS

AV	- acid value, mg $KOHg^{-1}$
D	- degree of elasticity for bulk rapeseed, %
D_e	- recoverable deformation of bulk seed, mm
D_p	- plastic deformation of bulk seed, mm
L_o	- compressing work till the oil point, J
PV	- peroxide value, mMol O_2 kg^{-1}
P_o	- pressure at the oil point, MPa
P_ε	- pressure at $e = 0.45$ mm/mm, MPa

*This work was supported by the State Committee for Scientific Research, Poland, under grant No. 5 S307 058 04

Δ_{1-3} - difference between the sieve weight of the first and third turn in agglomeration test, %

ε_o - strain at the oil point, mm/mm

τ - percolation time, s

MATERIAL AND METHODS

Above 50 rapeseed samples were taken, prior to and following drying, from industrial drum (SB 1.5) and chamber (Socama, M-817 and LAW) driers working in 15 drying plants in the North of Poland in June and July 1993. Samples were collected at random so the material was not variety homogeneous.

Seeds moisture was estimated by a drier method in triplicate [3].

An agglomeration test was performed acc. to Fornal *et al.* [2]. Seeds samples were crushed in uniform conditions and thrice sieved through the same noncleaned sieve with 0.63 x 0.63 mm eyelets, VEB Kombinat NAGEMA, Germany. Seeds quality was assumed as very good, good or medium, poor and very poor when difference between the first and third sieve weight, Δ_{1-3}, was up to 5 %, 10 %, 15 % and over 20 %, respectively. Determinations were made in triplicate.

Percolation of a solvent through the extracted layer was measured by the time of the solvent flow τ through a layer of seeds (grinded in uniform conditions) with height of 20 cm, in a column with a diameter of 6 cm, filled in the same way. Determinations were made in triplicate.

The oil point was determined using a modified version of the Sukumaran and Sing method [10]. Seeds were compressed in a metal, thick-walled container (surface area of the sample was 1 cm^2 and sample layer thickness 1.2 cm) applying relevant equipment of Instron model 1011, Instron Ltd, England. The crosshead speed was 10 mm/min. Reaching of the oil point was indicated by oil spots on a blotting paper stripe (2 mm x 20 mm) placed in the container. Pressure, P_o (MPa), strain, ε_o (mm/mm), and work, L_o (J), consumed for reaching of the oil point, have been accepted as the characteristic oil-point parameters. Determinations were made in 12 repetitions.

A compression test for bulk seeds was done with the same equipment. Pressure P_ε (MPa) at constant strain ε=0.45 mm/mm, which was the maximum strain not causing macrodamages, was measured. Elasticity degree of bulk seed layer, D (%), was calculated using equation according to Mohsenin [4]:

$$D = [D_e/(D_p + D_e)]100 .$$

Determinations with Instron 1011 were made in 5 repetitions.

The content of free fatty acids in the oil was estimated by an acid value expressed in mg KOH essential to neutralise 1 g of oil. The content of peroxides in the oil was estimated by a peroxide value expressed in Mmol of O_2/1 kg of fat [5]. Determination of both of the values was conducted in duplicate.

Germination power was made according to Polish Standards [7] in triplicate.

Analyses were performed on the air dried seeds of 6.5 % moisture (except germination power).

EXPERIMENTAL

Comprehensive evaluation of seed quality after harvest (control) and drying process was carried out and the following were analysed:

- seed germination power (Tables 1 and 2),
- seed processability with agglomeration test and the solvent percolation ability (Tables 1 and 2),
- oil quality characteristics with acid and peroxide values (Tables 1 and 2),
- macro- and microdamage (Tables 3 and 4),
- mechanical properties and ability to oil extraction from seeds (Tables 3 and 4).

The results are presented in separate tables for drum driers (Tables 1 and 3) and chamber driers (Tables 2 and 4) to be more clear.

Examination of rapeseed quality after harvest was not univocal. The results of the agglomeration test expressed by the difference in sieve weight Δ_{1-3} (in the range of 0.32 to 2.22 %) and solvent percolation time τ (26-43 s) showed good seed processability. Also acid value

Table 1. Quality of rapeseeds dried in drum driers

Seeds	Germination power (%)	Processability Δ_{1-3} (%)	Processability τ_p (s)	Oil quality AV (mg KOH/g)	Oil quality PV (mM O_2/kg)
raw	71	0.42	32	3.14	2.14
dried	4	1.71	41	1.56	6.66
raw	79	1.29	27		
dried	1	2.18	37		
raw	70	1.32	25		
dried	12	2.68	32		
raw	70	1.32	33		
dried	12	1.15	36		
raw	95	1.52	37		
dried	7	3.40	52		
raw	79	1.29	35		
dried	1	4.85	44		
raw	70	0.39	27		
dried	0	2.49	59		
raw	57	2.22	27	2.60	2.71
dried	0	6.20	38	2.40	10.40
raw	68	0.77	27	2.12	3.66
dried	8	5.74	39	1.51	4.91
raw	92	1.40	41	3.06	3.55
dried	14	1.64	73	2.28	4.22
raw	93	1.01	26		
dried	0	0.32	41		
raw	94	1.45	36		
dried	0	0.95	64		
raw	97	0.95	26	2.73	3.01
dried	9	2.86	97	1.72	11.23

Table 2. Quality of rapeseeds dried in chamber driers

Seeds	Germination power (%)	Processability Δ_{1-3} (%)	Processability τ_p (s)	Oil quality AV (mg KOH/g)	Oil quality PV (mM O_2/kg)
raw	97	0.95	26		
dried	90	0.86	31		
raw	82	0.66	43	1.85	3.41
dried	82	1.17	44	2.02	4.48
raw	40	1.29	35		
dried	38	1.44	42		
raw	58	0.46	35		
dried	37	1.45	37		
raw	70	0.39	35		
dried	68	0.84	35		
raw	85	1.30	34		
dried	50	2.08	43		
raw	87	0.61	33		
dried	69	2.52	35		
raw	70	1.31	34		
dried	65	2.86	38		
raw	97	0.95	26	1.97	3.32
dried	36	0.60	41	3.42	4.71

Table 3. Mechanical properties of rapeseeds dried in drum driers

Seeds	Damages		Oil-point test			Compression test	
	macro- (%)	micro- (%)	pressure (MPa)	deformation (mm/mm)	work (J)	pressure (MPa)	elasticity degree (%)
raw	6.0	1.7	8.44	0.472	1.60	8.59	71.5
dried	2.6	2.6	8.14	0.503	1.42	6.84	81.8
raw	1.2	0.7	8.23	0.431	1.61	9.35	70.8
dried	3.4	2.0	7.50	0.472	1.32	6.68	79.6
raw	3.9	5.0	8.05	0.462	1.50	8.12	75.7
dried	2.0	1.4	7.78	0.460	1.36	7.78	76.9
raw	3.9	5.0	7.90	0.463	1.50	8.12	75.7
dried	2.3	1.3	7.27	0.463	1.33	7.16	76.9
raw	1.7	1.3	9.21	0.442	1.75	10.12	75.7
dried	1.8	1.7	7.05	0.443	1.30	7.16	76.9
raw	1.2	0.7	8.23	0.431	1.61	9.35	70.8
dried	3.7	3.7	7.13	0.467	1.24	6.63	80.2
raw	2.5	3.3	8.33	0.427	1.58	9.45	72.9
dried	3.6	3.3	7.49	0.478	1.41	6.96	85.2
raw	3.1	2.0	8.51	0.448	1.69	9.07	84.5
dried	11.1	7.3	8.31	0.531	1.44	4.56	91.4
raw	7.2	5.0	8.80	0.461	1.81	8.61	70.9
dried	9.3	8.3	7.62	0.504	1.54	6.60	72.7
raw	2.2	1.7	9.56	0.462	1.98	9.49	73.0
dried	4.9	2.0	8.74	0.472	1.56	7.39	85.9
raw	2.3	2.3	9.16	0.446	1.93	10.12	75.6
dried	4.0	7.3	7.57	0.461	1.59	8.18	86.5
raw	1.7	3.0	8.98	0.432	1.80	10.03	78.4
dried	5.3	7.7	7.67	0.465	1.61	7.90	83.7
raw	2.5	0.7	9.42	0.429	1.75	11.71	77.5
dried	2.9	4.6	8.04	0.482	1.67	7.08	83.6

Table 4. Mechanical properties of rapeseeds dried in chamber driers

Seeds	Damages		Oil-point test			Compression test	
	macro- (%)	micro- (%)	pressure (MPa)	deformation (mm/mm)	work (J)	pressure (MPa)	elasticity degree (%)
raw	2.5	0.7	9.42	0.429	1.75	11.87	71.7
dried	2.3	1.6	8.67	0.421	1.66	9.60	78.0
raw	1.7	0.3	9.08	0.432	1.70	11.35	74.4
dried	2.0	2.3	8.80	0.429	1.63	9.26	73.5
raw	1.3	1.7	8.65	0.456	1.65	9.14	69.9
dried	3.1	0.3	8.38	0.448	1.57	9.24	78.9
raw	4.9	5.0	7.42	0.468	1.47	7.02	78.8
dried	4.5	7.0	7.29	0.470	1.37	6.84	86.0
raw	2.5	2.3	8.37	0.435	1.60	10.15	72.9
dried	2.3	3.3	8.33	0.427	1.59	9.45	72.9
raw	3.9	5.0	8.78	0.465	1.71	8.69	69.2
dried	4.2	6.7	8.36	0.466	1.69	8.40	75.7
raw	1.6	1.3	8.76	0.426	1.75	10.35	72.3
dried	2.7	1.0	8.32	0.440	1.62	9.32	83.6
raw	2.4	1.7	9.07	0.446	1.93	9.64	78.8
dried	2.9	1.7	7.97	0.448	1.59	9.38	83.6
raw	2.5	0.7	10.42	0.429	1.93	9.64	78.8
dried	3.0	6.0	8.74	0.443	1.87	9.23	83.6

(1.85-3.14) and peroxide value (2.14-3.66), which were within the limits accepted for raw oil, indicated a good quality of oil extracted from non-dried seeds (Tables 1 and 2). However, the usability of examined seeds as a sowing material was poor. The germinating power of seeds ranged from 57 % to 97 %, and as little as 18.1 % of seed samples were qualified as 1st class (according to the Polish standards).

Values of quality indices based on mechanical properties of seeds depend both on mechanical seed resistance and the variety of rapeseed [1]. The rapeseed variety was not identified in all cases. Thus, differentiation in mechanical properties of seeds, i.e., lower values of oil-point or compression test parameters ($7.43<P_o<9.56$ MPa, $1.465<L_o<1.981$ J and $8.12<P_\varepsilon<11.87$ MPa) do not have to indicate weak meachanical resistance of seeds (Tables 3 and 4). The low percentage of mechanically damaged post-harvest seeds pointed rather at variety variability of rapeseeds. The level of damage of most of the samples (100 % of samples referring to microdamages and approximately 90 % to macrodamages) falls within the range 1-5 % (Tables 1 and 3). In comparison with rapeseed harvested in 1991, more samples were found with 1, 2 and 5% damage and less with 3 and 4 %. However, the damage percentage of almost all the samples examined in 1991 is within the range 1-5 %. Thus, it should be considered that the damage level of the harvested rapeseed did not depart from the standard.

Industrial drying of seeds in both types of driers resulted in changes in the parameters studied but in most cases the changes were more evident after drying in drum driers.

Processability of dried seeds, according to the results of the agglomeration test, remained very good. Determined values of the sieve difference Δ_{1-3}, though generally higher than those for the non-dried seeds, slightly exceeded 5 % only in three cases (maximum value - 6.20 % for the sample 30, drier SB 1.5).

Percolation time for dried seeds was longer, but the increase for particular samples was not equal (Tables 1 and 2). On estimating the change in percolation time, the relative value, i.e., percolation time for dried seeds to raw seeds ratio τ_d/τ_r, was applied to balance the assumed variety variability of this parameter. The values of τ_d/τ_r for the seeds dried in chamber driers were, with one exception, within the range of 1.0-1.2, whereas in drum driers they were higher (1.19-3.73). It shows that the percolation time was longer for seeds dried in drum driers (Fig. 1).

The acid and peroxide values for the oil obtained from selected samples of dried seeds slightly exceeded the Polish standard. Two different tendencies showing an increase and a decrease of the acid value in oil from dried seeds, as compared to the oil obtained from raw seeds, were observed. The effect of temperature appeared mostly as an increase in AV caused by the oxidation of triglycerides and destruction of molecules into fatty acids. The decrease of AV might be probably explained by interactions of long-chain fatty acids with other seeds components, e.g., proteins, on heating of the seeds to 60-70 °C during drying. An increase of peroxide value in all oils was observed. It was fivefold in an extreme case that confirmed different decreasing oil quality (Tables 1 and 2).

The changes in germinating power were univocal. Only a few samples of the seeds dried in chamber driers preserved germinating power, while the majority of seeds samples dried in drum driers lost germinating ability.

The drying process lowered the mechanical resistance of seeds. The number of damaged seeds increased, whereas the P_o and L_o values decreased (Tables 3 and 4). Similar changes are also confirmed in other papers [6,9]. P_o, L_o and P_ε values are generally lower for the seeds dried in drum driers. Tendencies for changes in mechanical properties of seeds both dried and undried are presented in Fig. 1 using respective P_ε values, which are closely correlated with L_o and P (correlation coefficients are higher than 0.9) so represent all parameters of oil-point and compression tests very well. It was established that the mechanical

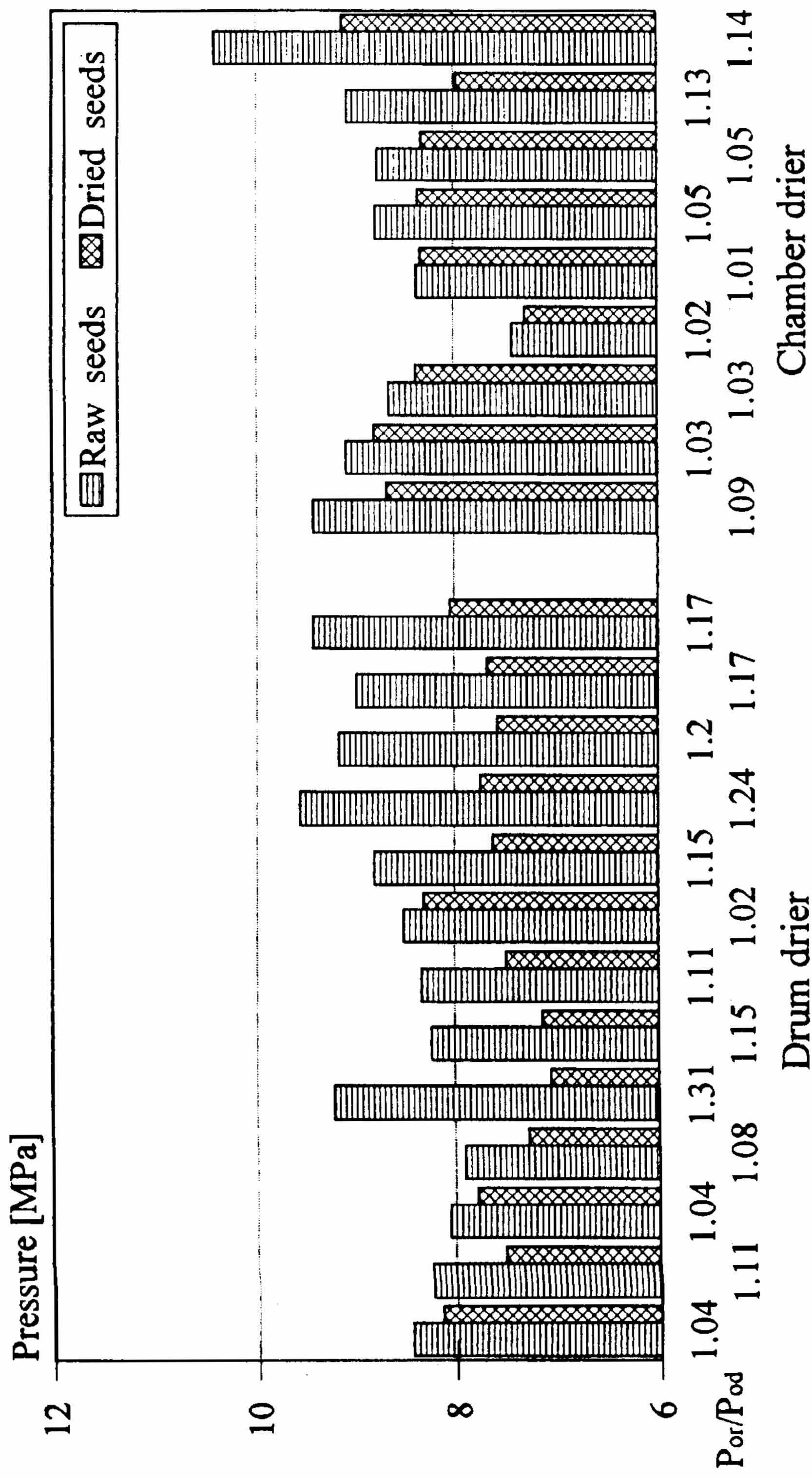

Fig. 1. Pressure at oil point for raw and dried rapeseeds with respective P_{or}/P_{od} indices.

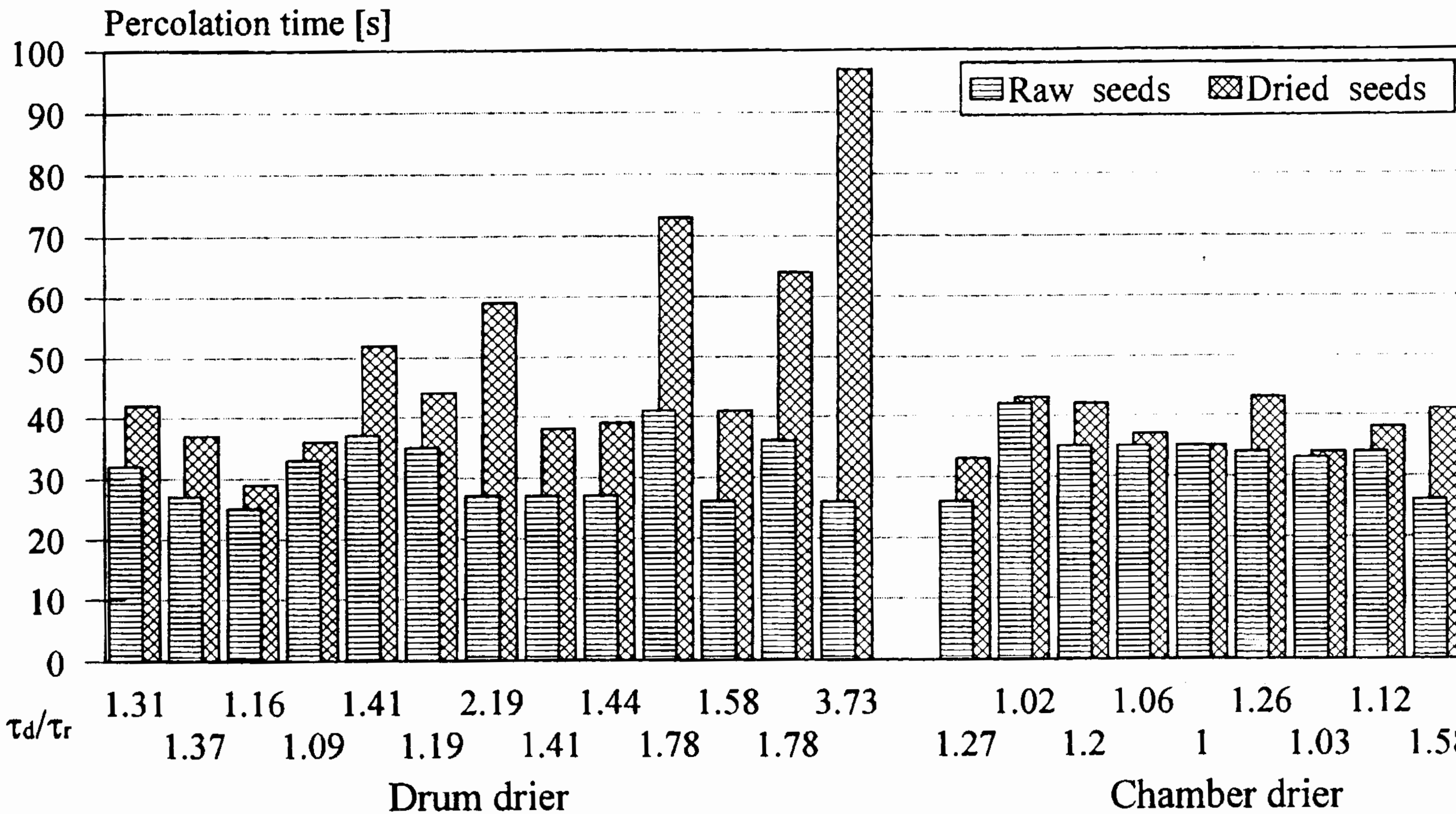

Fig. 2. Percolation time at oil point for raw and dried rapeseed layer with respective τ_d/τ_r indices.

resistance of seeds depends also on the variety of rapeseed [1]. Thus, a comparison in the mechanical resistance decrease is possible only when an index, including the different initial level of this resistance, is applied. The ratio of raw seeds P_o to dried seeds P_o, i.e., P_{or}/P_{od} was calculated in a similar way as the τ_d/τ_r ratio. For the seeds dried in drum and chamber driers P_{or}/P_{od} values were within the range 1.024-1.234 and 1.000-1.144, respectively, which indicates a higher decrease in mechanical strenght of drum dried seeds.

A similar general trend in changes of τ_d/τ_r and P_{or}/P_{od} values was observed. However, the correlation between the indices τ_d/τ_r and P_{or}/P_{od} appeared to be weak - correlation coefficients were 0.566 and 0.661, respectively, for drying in drum and chamber driers. The relation between the lowering of mechanical resistance of seeds and the extended percolation time was confirmed earlier [2,8] then the differentiation of varieties and a slight weakening of the examined seed microstructure might be the explanation of this unexpected results.

Other parameters, presented in Tables 3 and 4, for the deformation at the oil point and a degree of elasticity, had mostly the values recognized for dry but not overdried seeds [8]. The degree of elasticity of seeds is higher for dried seeds. It can result from the stronger shrinkage of cotyledons than a hull, which causes air spaces to form. The deformation at oil point for dried seeds changed irregularly, admitting higher or lower values in comparison with the raw seeds. The deformation at oil point is usually higher for dried seeds than the analogical raw seeds, because of the presence of the air space between the cotyledons and a hull. The values of deformation for dried seeds were in this case unexpectedly low. The smaller shrinkage caused low initial content and low decrease in the mechanical resistance of seeds, which were probably the reasons for the decrease in elasticity of dried seeds.

On summing up the obtained results it should be stressed that processability of all the seeds studied was good. Thus, it can be assumed that the raw quality of the seeds dried in drum driers may have resulted from not controlling the recommended drying parameters, mainly the drying temperature.

REFERENCES

1. **Fornal J., Jaroch R., Sadowska J., Kaczyńska B.:** Mechanical properties of rapeseeds of selected varieties and strains (in Polish). Zesz. Probl. IHAR, I, 165-179, 1991.
2. **Fornal J., Sadowska J., Jaroch R., Kaczyńska B., Winnicki T.:** Effect of rapeseed drying on their mechanical properties and technological usability. Int. Agrophysics, 8(2), 215-224, 1994.
3. IUPAC Standard Methods for the Analysis of Oils, Fats and Soaps. 5th Edition, 1966.
4. **Mohsenin N.N.:** Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers, New York-London-Paris, 1970.
5. Official Methods of Analysis of the AOAC. (Ed.: K. Helrich). 2, 777, 1990.
6. **Pathak P.K., Agrawal Y.C., Singh B.P.N.:** Effect of elevated drying temperature on rapeseed oil quality. J. AOCS, 68(8), 580-582, 1991,
7. Polska Norma PN-78/R - 65023
8. **Sadowska J., Fornal J., Szmatowicz B., Ostaszyk A.:** Estimation of technological quality of dried rapeseed. P. J. Fd Nutr. Sci., 3/44(4), 95-104, 1994.
9. **Stępniewski A., Szot B., Fornal J., Sadowska J.:** Drying conditions and mechanical properties of rapeseed. Proc. 1st Int. Conf. Food Phys., Budapest, 10, 1994.
10. **Sukumaran C.R., Singh B.P.:** Compression of a bed of rapeseeds: The oil point. J. Agric. Engng. Res., 42, 77-84, 1989.

OCENA TECHNOLOGICZNEJ JAKOŚCI NASION RZEPAKU SUSZONYCH W SUSZARKACH PRZEMYSŁOWYCH

Ponieważ często zdarzało się, że nasiona rzepaku dosuszane po zbiorze nie nadawaly się do przerobu dwustopniowego (brak perkolacji rozpuszczalnika umiemożliwiał ekstrakcję oleju) pobrano do analizy próbki nasion ze zbiorów 1993 r. suszonych w przemysłowych suszarkach bębnowych SB 1.5 i komorowych (Socama, M-817 i LAW). Przeprowadzono ocenę jakości nasion po zbiorach i po suszeniu analizując: zdolność kiełkowania nasion, technologiczną przydatność nasion ocenianą testem aglomeracji i czasem perkolacji rozpuszczalnika przez warstwę rozdrobnionych nasion, jakość oleju pozyskanego z wybranych prób nasion mierzoną liczbami kwasową i nadtlenkową, stopień makro- i mikrouszkodzeń nasion oraz właściwości mechaniczne i zdolność wyolejania nasion.

Ocena jakości nasion po zbiorach nie była jednoznaczna. Przydatność technologiczna nasion i jakość oleju surowego była dobra lecz zdolność kiełkowania nasion była bardzo słaba. Nasiona charakteryzowały się stosunkowo niską odpornością mechaniczną (niskie wartości punktu olejowego) choć stopień uszkodzeń nasion po zbiorze był niski.

Przemysłowe suszenie nasion w suszarkach tak bębnowych jak i komorowych powodowało zmiany wartości wszystkich badanych parametrów, wyrazistsze po suszeniu nasion w suszarkach bębnowych. Wskaźniki eliminujące zróżnicowanie nasion po zbiorach tj. τ_{susz}/τ_{sur} (do oceny wydłużenia czasu perkolacji) i Po_{sur}/Po_{susz} (do oceny obniżenia odporności mechanicznej nasion) potwierdziły także silniejsze zmiany w nasionach suszonych w suszarkach bębnowych. W danych warunkach (poprawne sterowanie procesem suszenia, nasiona o stosunkowo niewysokiej początkowej wilgotności) technologiczna jakość wszystkich suszonych nasion pozostała poprawna. Sądzić zatem należy, że obserwowane obniżenie jakości nasion podczas suszenia może być przyczyną dyskwalifikacji partii tylko w przypadku suszenia nasion o wysokiej wilgotności początkowej. W praktyce, w tych przypadkach wydłuża się najczęściej czas suszenia co może prowadzić do przesuszenia nasion powodującego ich nadmierną kruchość. Przesuszenie szczególnie łatwo może się zdarzyć w suszarkach bębnowych SB 1.5, w których stosuje się wyższe temperatury suszenia.

Słowa kluczowe: nasiona rzepaku, olej rzepakowy, przydatność technologiczna, suszenie przemysłowe, właściwości mechaniczne, zdolność kiełkowania.