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REPORT

SUBJECT Research On Flaxseed
a. College of Agriculture
Olsztyn

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1. a report on a Polish research project (27 pages, English) entitled "The Influence of Storage Changes in Flaxseed on Quality of Seed and Properties of Linseed oil." The project is being conducted by Dr A Rutkowski, Department of Food Technology and Storage, College of Agriculture, Olsztyn, Poland.

2. The nature of the chemical and biochemical deteriorative changes of flux in storage is assumed to be similar to those in grains but little actual research has been conducted on this subject. FOR OFFICIAL USE ONLY

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Annual report

1. COLLEGE OF AGRICULTURE IN OLSZTYN /POLAND/
   Department of Food Technology and Storage

2. Prof. dr A. Rutkowski, head of the Department

3. Studies on the flaxseed storage, and the chemical changes at this period

4. E 21 - AMS - 6

5. FG - Po - 121 - 62

6. 1.I.1962 to 31.XII.1962.

S u m m a r y

Previously, no thorough studies vere conducted in Poland with purpose to determine technological values of linseeds and especially those of oil, obtained from Polish flax varieties.

The present studies involved following problems:

1/ Characteristics of commercial linseed obtained from different varieties in various parts of Poland. The main part of this work was carried out in 1961, and the whole was terminated in 1962.
Although 40 samples of linseed and oil obtained form different varieties in various parts of Poland were investigated, no statistically proved conclusions could be drawn relating to the characteristics of individual flax varieties.

2/ Quantitative changes of principal components in linseed, and especially of oil were followed in the time of ripening. This problem is very interesting, fibrous flax being the important source of raw material for Polish fat industry. These are harvested before they become fully ripe, therefore they represent an another stage of maturity than oleiferous flaxes do.

3/ 36 samples of linseed were studied to compare technological values of commonest Polish varieties. These samples represented six Polish varieties and were obtained by field experiments situated in 3 centers of this country.

4/ The previous studies howed that the changes in oil composition were mainly influenced by the climate, and especially by temperature and air moisture. Therefore, the special pot experiments were prepared in seven centres with various climatic conditions. On the basis of these experiments, 4o samples of six commonest Polish varieties were selected for further investigations.

D e t a i l e d R e p o r t

1. Introduction

Previous studies on technological values of linseeds paid much attention to flax varieties grown in North America, India, Russia and West Europe. But no thorough researches have been undertaken of flax varieties grown in Poland. In view that fibrous flaxes are cultivated to much extent in Poland, and the linseeds obtained from these varieties provide an important source of raw material for fat industry, it appeared reasonable to involve these flax varieties in the present studies.

In order to define the diferences of oil content and oil composition between individual flax varieties, the studies were conducted not only with commercial linseeds, but also with those obtained from field experiments, especially prepared for these purposes.

The previous studies, and especially the findings of Yermakov, /1/ showed that during ripening individual fatty acids are accumulated with various intensity depending on climatic factors. In northern climatic zone, the iodine value was found to increase continuously during the vegetative stage. This fact indicated, that the unsaturated acid percentage augmented trhugh the time of ripening. In southern zone, however, in steppe regions with high temperatures and low air moisture, I.V. reduction was observed in the final period of maturation. It indicates that saturated acid formation occured at higher rate at that stage.

It was very interesting to know, how the fatty acids were synthetized in the climatic region of Poland. Qualitative and quantitative changes of oil occuring in the time of ripening were followed on linseeds of LCSD- 200 variety, which had been obtained from our own experimental plots. These studies resulted in settling the question, how the technological value of oil might be influenced by earlier harvesting of fibrous flaxes.

Recently much has been reported about the effect of climatic factors, and especially that of temperatures and air moisture, which were originally studied by Pigulevski /2/ and Ivanov /3/. These findings indicated, that quantitative distribution of unsa-

turated acids in plant oils was essentially influenced by climatic conditions. In the case of linseeds, that is determinative for their technological quality.

Altough Poland does not occupy a great area, as its latitude is concerned, its climate appears to be considerably varied. Therefore it was believed, that the role of climatic factors could not be neglected when the attempt was made to define all characteristics of linseed as raw material for industry. This question was answered on the basis of evidence obtained by pot experiments which were established in various climatic regions of this country.

2. Experimental procedures

Test material.

a/ In further studies about the general characteristics of linseed, 11 samples of commercial linseeds were investigated. They were obtained from six varieties grown in various part of Poland.

b/ Flax variation LCSD-200 obtained from our own experimental plot was chosen to observe quantitative and qualitative variations resulting from different stages of maturity. The plot was devided in 16 smaller plots, the area of each being 16 m^2. Site preparation, sowing and cultivaion were performed according to generally accepted agrotechnical principles. As the plants became bushy and they extremelly varied in their blooming time, the studies involved exclusively bolls issued from flowers which were formed in the earliest time /these were light distinguishable from others/. This procedure permitted the samples to be chosen which were characterized by relatively even stage of maturity. /The highest difference was 2 - 3 days/.

100 bolls were harvested from each plot. Subsequently, crops from all plots were mixed together to obtain an average sample. Bolls were hulled next to harvesting and seeds were collected into little glass vessels with adjusted lids. Once the whole sample had been hulled, seeds were mixed thoroughly and determinations began. Samples were taken every seven days, to begin with fourteenth day after blooming.

c/ In order to determine variety differences in oil content and composition, field experiments were established in three following centers: at Olsztyn - block experiments in four replicas; at Giby and Rzeszów - no replicas. The studies involved six following varieties which are the commonest ones in Poland: two oleiferous varieties, Kotwiecki and LCSD-200, and four fibrous varieties, LCSD-207, LCSD-210, Swadzimski and Lazur.

d/ The influence of climatic factors was observed on linseeds obtained by pot experiments. The varieties mentioned under c/. were used. Pot experiments were established in 7 centres with different climatic conditions. /Annual Report 1961, Map No 3/. In each centre, every variety was sown in four parallel Mitaherlich pots. Pot experiment principles were strictly observed /4/ in these studies. Experimental soil was prepared simultaneously for all centres at Olsztyn. Through the vegatation period, the pots were weighed and watered every day, to maintain the soil moisture on the level of about 60% of its water capacity. They were installed on handcarts standing near vegatation rooms and were brought under a glass roof when it was raining. At Giby and Rzeszów, where no vegetation rooms were available, the pots were standing on wooden stools and a igelite foil roof was spread out over them to protect them from rain. Once each variety became fully ripe, crops were harvested. To obtain an average sample, crops of four parallel pots were mixed before testing.

Methods

1. The weight of 1000 grains is a mean value, which was obtained by weighing 4 x 250 grains.
2. I.V. was determined by Wijs method, according to AOCS Official Methods L 8a - 57.
3. Mono-,di-,and triglyceride content was determinated according to Quinlin and Weser /5/.
4. Total 1- and 2-monoglycerid content was determined by Brokow's procedure /6/.

5. 1-monoglycerid and glycerol content was determined by Kruta's method /7/. Other determinations were made by using the same methods that were mentioned in Annual Report for 1961.

3. Results

a. Commercial linseeds were studied in 1961 and 1962. In 1961, the studies were made of 18 samples which were obtained from crops harvested in 1960. 5 linseed samples of 2 oleiferous flax varieties and 11 samples of 5 fibrous varieties were investigated. All were taken from 8 centres situated in various parts of Poland. The results of seed and oil analyses are shown in the tables 1 and 2, respectively.
In the year 1961-62 22 samples of commercial linseeds were investigated. They originated from crops harvested in 1961. The studies encompassed 11 samples of 2 oleiferous varieties and 11 samples of 5 fibrous varieties. The samples were taken in the same centres, as those of previous year were. The analysis results are summarized in the tables 3 and 4.

b. Studies on quantitative and qualitative variations of linseed oil, which was obtained from seeds at various stages of maturity gave results summarized in the table 5.
The diagram 1 represents the changes in dry weight and oil content, as they were calculated per 100 grains as well the changes in oil content expressed as percentage of dry matter. The changes in unsaturated fatty acids content are shown on the diagram 2, as they are expressed in percentage and in mg/100 grains.
The changes in lipolytic activity as calculated per 1000 grains and FFA content are shown on the diagrams 3 and 4, respectively.

c. The results of studies wigh linseeds of six commonest Polish varieties are summarized in the table 6. These results are groupped by varieties. Data for Olsztyn are mean values as obtained from four replicas /block experiments/.
The results in tables 7, 8 and 9 are groupped by experimental centres.

The variety differences in the content of principal components were determined by amplitude /difference between the highest result and the lowest one and confidence interval/.
Results of linseed studies which were obtained by pot experiments with six commonest Polish varieties are summarized in tables: 10, 11, 12, 13, 14 and 15, according to varieties. Differences in content of principal component, as they were found in individual varieties, were defined by amplitudes and confidence intervals.

4. Discussion

a. The obtained results of oil content in the sample of commercial linseeds confirmed the findings by various authors who studied flax varieties in other countries, viz: oil content was more influenced by climatic conditions than it was by variety properties /8,9/.
The data for crops of 1960 indicated, that the oleiferous varieties, such as Kotowiecki and LCSD-200, tended to show higher oil content, but this found no confirmation in the results obtained for the same varieties when harvested in 1961.
Similarly, the results relative to physical and chemical properties of oil did not allow to draw reasonable conclusions about variety differences.
There was a striking discrepancy between the results of polyunsaturated fatty acid determinations obtained by paper chromatography and those obtained by spectrophotometric procedure.

b. The accumulation mechanism of oil and individual fatty acids could be explained by investigations on qualitative and quantitative changes of oil, which was obtained from linseeds harvested at various stages of maturity. Diagram 1 shows, that the oil content, as calculated per 100 grains, increased through the period of ripening, and that 85% of final amount was still accumulated at 28 days after blooming./green maturity/.
The increase of oil content, as expressed in dry weight percentage, proceeded up to the moment of attaining green maturity i.e. 28 days after blooming, and than it remained nearly

at the same level. From diagram 2 it appears, that accumulation process of individual unsaturated fatty acids did not always occured on the identical way.

The highest persentage of oleic acid was found in the first test series, i.e. at 14 days after blooming time. Subsequently, the reduction of its content was observed, the minimum being reached by green maturity /28 days after blooming/. A slight increase followed, and than the almost constant level was mainteined, as measured in mg/100 grains, oleic acid content increased very rapidly up to the time of green maturity; at next seven days, its content was found to be reduced, and than a slight increase was observed up to the time of full maturity.

Reduced absolute content of oleic acid would indicate the occurance of desaturation process. This was not reported in previous studies and is rather to be considered as resulting from determination error. /oleic acid content was calculated from the content of linoleic and linolenic acids and iodine value/. Therefore it seems more probable, that oleic acid accumulation proceeded very rapidly up to 21 days after blooming and than it became slower till the full maturity was attained.

The percentage of linoleic acid increased rapidly in the first period of ripening /up to 21 days after blooming/ and than it decreased with the minimum reached at yellow maturity 1/. At full maturity, a slight increase of its content was observed.

The mg/100 grain content of linoleic acid increased evenly up to 35 days after blooming, and than oly slight changes were observed.

The percentage of linolenic acid tended to increase up to the stage of green maturity; at that time it attained about 85% of content, which was found at full maturation. The further slower increase was observed up to 42 days after blooming. Therafter, no significant changes were found.

The iodine value showed a rapid increase up to the time of green maturity, followed by a very slow increase up to the period of full maturity.

1/ About 35 days after blooming

In the time of ripening free fatty acid content was found to drop rapidly from 1,24% to 0,35%. That is shown on diagram 4. Lipase activity in linseeds became strongly reduced, as ripening went on /diagram 5/.
No significant changes in mono-, di-, and triglycerides could be detected by using column chromatography method.
When determined by chemical procedure, total monoglyceride content appeared to decrease, as ripening went on.

c. The results of investigations involving different varieties of linseed and oils, which were obtained from them, and influence of climatic factors will be discussed in the next Annual Report, the assays being intended to be repeated in 1963.

5. Conclusions

a. The results of studies made whith samples of commercial linseeds and with oils obtained from them did not permit to draw conclusions about variety differences, plants being more influenced by conditions, under which they grew than by inherent properties of varieties. Therefore it appeared necessary to establish field experiments, to prevent the differentiating effect of environment. The results were obtained, however, which afforded many valuable data for the estimation of technical value of linseeds obtained from different varieties which are cultivated in nearly all parts of Poland. That matter was not treated in previus studies.

b. From obtained results it can be concluded, that the technical value of oils obtained from fibrous flax should not be impaired by the necessity of earlier harvesting, because quantitative proportions between individual fatty acids were not significantly changed when passing the stage of green maturity. Earlier harvesting can result in reduced oil yield.

c. Conclusions about variety differences and effect of climatic factors will be drawn in 1963, when the last year experiments have been repeated.

6. Plan for future work

a. Reproduction of studies concerning varieties and influence of climatic factors, on the basis of evidence obtained by field and pot experiments.

b. Investigation of quantitative and qualitative changes of oil obtained from linseed stored in unfavorable conditions.

c. Characteristics of amino acid composition in linseed proteins.

d. Characteristics of lipolytic enzymes of linseeds.

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Results of linseed analyses /crop of 1960/

Table 1

Ser No	Sample No	District	Variety	Kind of use	Fat %	Ash %	Moisture %	Dry matter %	Fat in dry matter %	Ash in dry matter %
1.	1.	Poznań	LCSD-200	Oleagine-ous	36.44	3.74	8.07	91.93	36.64	4.06
2.	4.	"	LCSD-200	"	40.95	3.64	5.32	94.68	43.25	3.84
3.	5.	"	Ród -021	"	41.15	3.59	5.16	94.84	43.39	3.78
4.	6.	"	Ród -179	"	38.99	4.18	6.85	93.15	41.87	4.48
5.	2.	"	Kotowiecki	"	37.16	3.55	7.68	92.23	40.25	3.84
6.	7.	Wrocław	LCSD-210	fibrous	32.02	3.60	9.76	90.24	35.48	3.98
7.	9.	Białystok	"	"	33.44	3.97	9.18	90.82	36.82	4.37
8.	10.	Warszawa	"	"	35.06	4.12	11.28	88.72	39.52	4.64
9.	12.	Bydgoszcz	"	"	36.30	3.74	11.34	88.66	40.94	4.21
10.	13.	Bydgoszcz	"	"	35.39	4.03	10.57	89.43	39.57	4.50
11.	8.	Wrocław	Lazur	fibrous	32.90	3.57	9.96	90.04	36.54	3.96
12.	14	"	"	"	34.09	4.27	9.08	90.92	37.49	4.69
13.	15.	"	"	"	36.41	3.86	9.13	90.87	40.07	4.24
14.	11.	Rzeszów	Swadzimski	fibrous	35.63	3.62	10.45	89.55	39.79	4.04
15.	16.	Opole	"	"	32.47	3.63	11.97	88.03	36.88	4.19
16.	17.	"	"	"	33.41	3.60	11.45	88.55	37.73	4.06
17.	3.	Olsztyn	Wiera	fibrous	36.73	3.60	8.55	91.45	40.16	3.93
18.	18.	Wrocław	LCSD-207	fibrous	34.20	3.80	9.66	90.34	37.75	4.02

Results of linseed oil analyses /crop of 1960/

Table 2

Ser No	Sample No	IV	SV	Ref. index n^{20}_D	U.V. Spectro - photometry		Paper partition chromatography				FFA	PV
					Lindeic acid %	Linde-nic acid %	Lindeic acid %	Linde-nic acid %	Oleic and palmi-tic acid %	Stearic acid %		
1.	1.	188.5	.....	1.4754	11.88	57.10	15.93	43.25	32.81	8.00	3.31	1.5
2.	4.	.....	187.05	1.4791	12.28	58.43	13.33	45.84	29.14	11.69	1.50	1.6
3.	5.	184.4	186.30	1.4759	.....	.....	12.50	46.10	35.97	5.43	1.52	1.3
4.	6.	196.1	185.00	1.4756	12.24	56.35	14.66	47.20	30.00	8.14	1.16	0.8
5.	2.	.....	194.95	1.4759	12.27	55.25	13.48	45.50	31.90	9.12	2.82	0.8
6.	7.	189.5	.....	1.4769	12.24	56.35	16.59	44.96	29.26	9.19	2.29	0.7
7.	9.	.....	.....	1.4689	.....	.....	13.60	50.45	28.99	6.95	3.53	3.2
8.	10.	184.2	.....	1.4723	11.07	56.92	15.39	47.53	30.83	6.25	5.97	1.5
9.	12.	190.6	.....	1.4729	11.11	57.68	13.25	46.30	30.95	9.50	4.41	4.1
10.	13.	.....	.....	1.4725	11.48	54.24	14.05	41.94	36.81	7.20	5.23	2.7
11.	8.	186.2	188.50	1.4779	13.70	56.93	13.36	51.57	26.78	8.29	1.37	0.5
12.	14.	197.2	.....	1.4745	12.22	58.06	13.61	53.54	24.91	7.94	1.63	0.8
13.	15.	190.2	186.60	1.4774	14.23	57.88	14.64	48.34	19.72	17.30	3.65	1.2
14.	11.	197.8	.....	1.4633	12.51	60.18	11.46	55.92	25.65	6.97	1.56	2.1
15.	16.	195.9	.....	1.4787	14.28	58.65	9.63	57.36	28.13	4.88	3.86	1.5
16.	17.	.....	194.80	1.4772	15.86	57.31	16.69	53.01	23.53	6.77	.....	3.2
17.	3.	195.2	185.35	1.4773	13.57	60.19	16.43	51.11	22.20	10.25	1.36	1.5
18.	18.	190.3	.....	1.4762	14.28	56.16	14.72	51.45	25.88	7.95	2.34	1.9

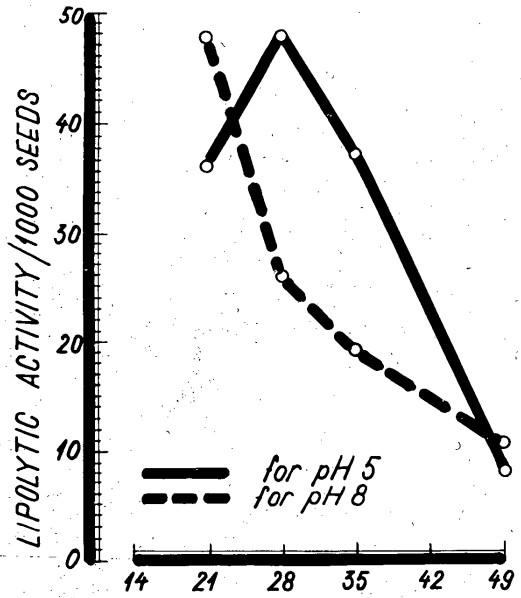

FIG. 3. RELATION BETWEEN LIPOLYTIC ACTIVITY FOR pH 5 AND 8 AND DAYS AFTER FLOWERING

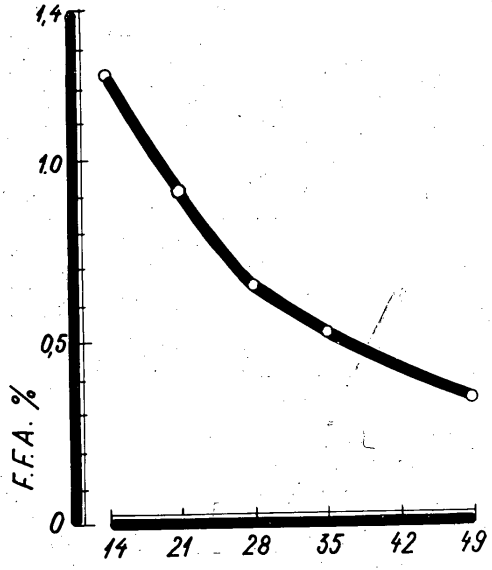

FIG. 4. F.F.A. CONTENT AS A FUNCTION OF DAYS AFTER FLOWERING

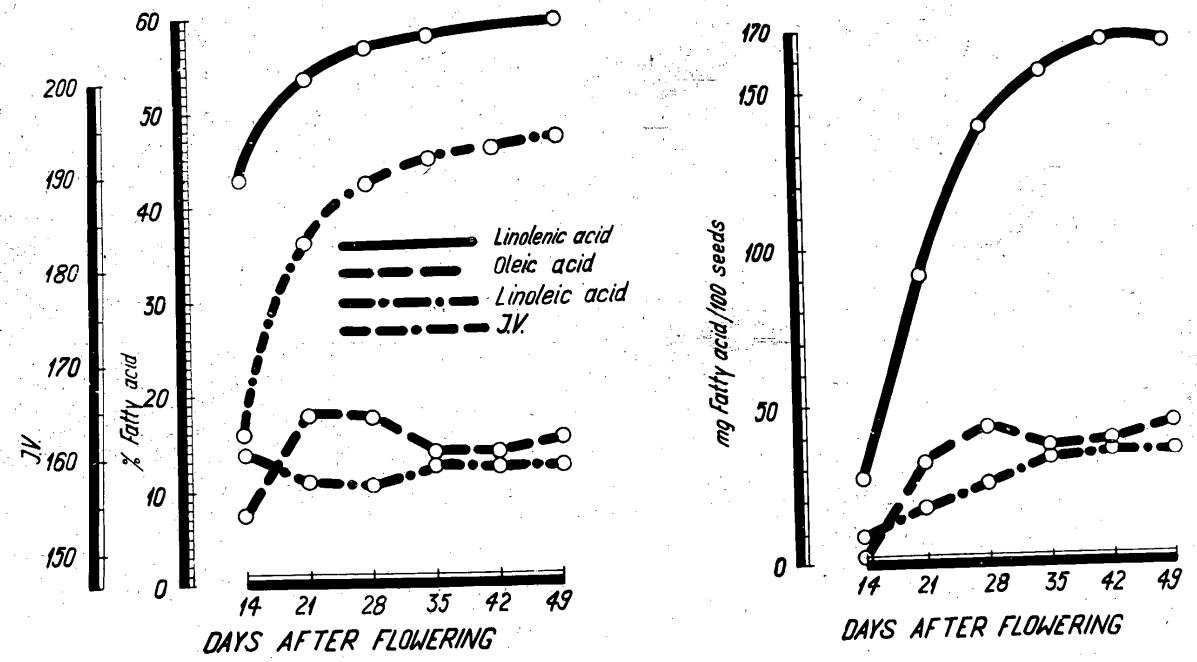

FIG. 2. KONCENTRATION OF INDIVIDUAL FATTY ACIDS IN OIL FROM LCSD-200 FLAX AS FUNCTION OF DAYS AFTER FLOWERING

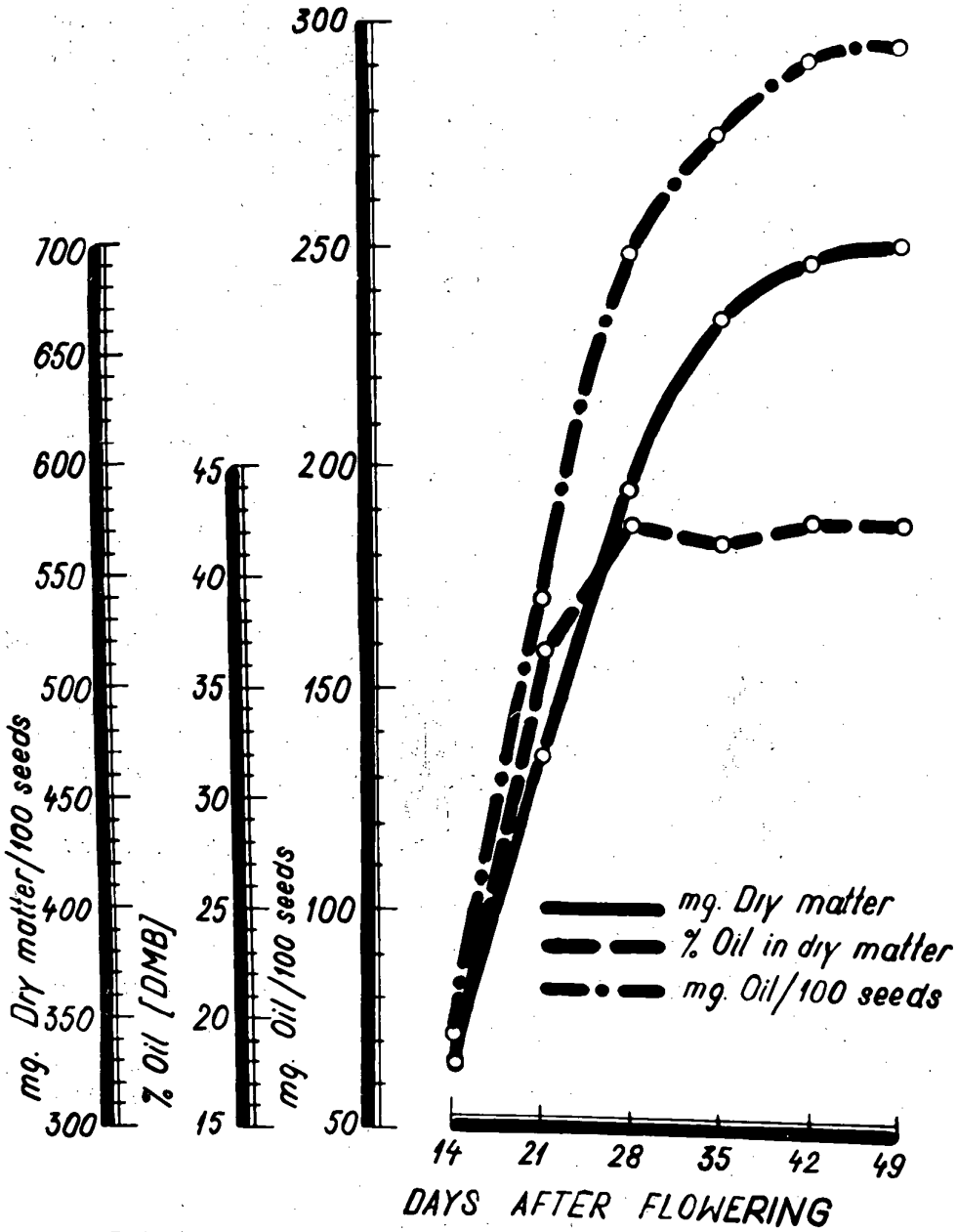

FIG. 1. DRY MATTER AND OIL IN THE SEEDS DURING A FLAX RIPENING

Results of linseed analyses /crop of 1961/

Table 3

Ser No	Sample No	District	Variety	Kind of use	Fat %	Row protein %	Ash %	Moisture %	Dry matter %	Fat in dry matter	Protein in dry matter %	Ash in dry matter
1.	20	Poznań	Kotowiecki	Oleagineous	31.23	23.25	3.69	7.12	92.88	33.62	25.03	3.97
2.	22	"	LCSD-200	"	31.65	22.06	3.44	7.01	92.99	34.03	23.72	3.69
3.	23	"	Ród -021	"	33.35	26.19	3.33	6.82	93.18	35.78	28.10	3.57
4.	24	"	Ród -075	"	30.83	24.44	3.70	6.77	93.23	33.78	26.21	3.96
5.	25	"	Ród -055	"	31.50	24.81	3.80	6.97	93.03	33.12	26.66	4.08
6.	26	"	Ród -179	"	27.13	22.19	3.62	7.44	92.56	29.31	23.97	3.91
7.	27	"	Ród -108	"	29.25	21.56	3.51	7.41	92.59	31.59	23.28	3.79
8.	28	"	R-BL-k80/58	"	31.62	23.06	3.71	7.52	92.48	34.19	24.93	4.01
9.	29	"	R-LB-k3470/58	"	29.71	25.13	4.14	7.14	92.83	32.00	27.07	4.45
10.	30	"	R-BK-k663/58	"	27.40	23.00	3.49	7.34	92.66	29.55	24.82	3.76
11.	41	Bydgoszcz	LCSD-200	"	34.23	24.03	3.33	9.59	90.41	37.97	26.58	3.68
12.	21	"	LCSD-210	Fibrous	31.16	23.44	3.67	6.99	93.01	33.50	25.20	3.94
13.	37	"	LCSD-210	"	31.19	24.87	4.02	10.04	89.96	34.67	27.64	4.47
14.	31	Białystok	LCSD-210	"	32.28	26.31	3.78	8.02	91.98	35.09	28.60	4.11
15.	32	Warszawa	LCSD-210	"	30.73	25.81	3.96	7.93	92.07	33.37	28.03	4.30
16.	39	Poznań	LCSD-210	"	29.07	24.00	3.90	10.40	89.60	30.80	26.78	4.35
17.	33	"	Lazur	"	28.40	25.00	3.72	8.06	91.94	30.88	27.19	4.05
18.	35	Wrocław	Lazur	"	31.38	23.88	3.71	7.35	92.65	33.86	25.77	4.00
19.	36	Opole	Swadzimski	"	27.84	24.31	3.45	9.78	90.22	30.85	26.94	3.82
20.	40	Rzeszów	Swadzimski	"	31.26	21.12	3.35	6.91	93.09	33.57	22.69	3.60
21.	34	Olsztyn	Wiera	"	31.67	23.19	3.37	6.59	93.41	33.90	24.83	3.61
22.	38	Wrocław	LCSD-207	"	28.62	22.62	3.80	10.58	89.42	32.00	25.30	4.25

Results of linseed oil analyses /crop of 1961/

Table 4

Ser No	Sample No	I.V.	Ref. index n^{20}_{D}	S.V.	Density at 20°C	Viscosity at 20°C cP	Unsap. Mat. %	U.V. Spectrophotometry		Paper partition chromatography				FFA	PV
								Linoleic acid %	Linolenic acid %	Linoleic acid %	Linolenic acid %	Oleic and palmitic acids %	Stearic acid %		
1.	20	179.7	1.4811	188.32	0.9310	46.55	0.77	12.13	52.71	11.77	49.20	34.48	4.54	0.407	0.9
2.	22	193.2	1.4828	187.67	0.9340	44.16	0.76	11.57	59.99	8.04	56.12	28.20	7.63	0.287	0.1
3.	23	184.9	1.4821	188.12	0.9320	45.15	0.77	8.78	59.22	12.03	56.73	26.57	4.66	0.305	0.7
4.	24	191.6	1.4825	190.16	.....	.....	0.80	7.25	62.12	11.62	51.53	30.95	5.90	0.353	0.4
5.	25	191.5	1.4827	189.79	0.9325	44.71	0.82	10.29	59.80	8.71	54.66	32.85	3.77	0.245	1.1
6.	26	193.7	1.4828	191.06	0.9320	44.18	0.76	11.50	60.75	14.19	50.66	30.42	4.72	0.325	1.2
7.	27	194.1	1.4831	190.26	0.9316	44.07	0.76	11.62	62.29	12.17	58.60	24.91	4.32	0.348	0.1
8	28	192.0	1.4828	189.34	0.9310	43.96	0.72	12.01	60.16	10.91	55.88	25.83	7.38	0.212	0.1
9.	29	191.4	1.4826	189.77	0.9309	43.86	0.80	11.18	60.57	13.27	50.57	31.60	4.55	0.179	0.1
10.	30	184.8	1.4817	188.86	0.9297	45.64	0.77	14.55	53.67	13.90	49.38	29.50	7.22	0.180	0.1
11.	41	189.6	1.4830	191.49	0.9323	44.79	0.82	12.93	56.35	13.62	60.87	22.30	3.21	0.807	0.1
12.	21	194.9	1.4830	189.27	0.9314	43.75	0.73	10.45	61.14	9.91	59.83	26.56	3.69	0.899	0.7
13.	37	185.7	1.4826	191.66	0.9316	44.92	0.72	13.67	53.10	14.19	55.25	24.86	5.70	0.138	0.2
14.	31	190.0	1.4823	191.22	0.9319	45.79	0.92	11.34	53.29	14.95	55.83	25.07	4.15	0.154	0.6
15.	32	187.5	1.4822	191.21	0.9326	46.00	0.75	12.10	51.75	12.95	56.68	26.73	3.64	0.100	0.1
16.	39	185.8	1.4826	191.43	0.9325	44.84	0.76	13.27	52.93	12.78	61.10	22.88	3.24	0.191	0.5
17.	33	194.0	1.4830	190.72	0.9335	45.19	0.69	14.35	54.34	18.54	48.56	25.33	7.57	0.095	0.1
18.	35	191.3	1.4830	191.81	0.9322	43.45	0.75	14.30	55.97	16.33	52.23	20.71	10.73	0.114	0.3
19.	36	184.5	1.4826	192.59	0.9324	44.91	0.73	14.82	52.71	12.99	58.82	21.24	6.95	0.117	0.4
20.	40	189.4	1.4828	190.20	0.9328	46.37	0.85	14.42	54.17	15.86	54.05	28.51	1.58	0.170	0.6
21.	34	187.8	1.4831	191.09	0.9336	44.33	0.68	15.54	55.39	20.14	50.19	23.26	6.41	0.311	0.1
22.	38	188.8	1.4832	190.33	0.9331	45.86	0.85	13.85	55.38	15.45	53.66	28.68	2.21	0.166	0.4

Tablela 5

Results of linseed and linseed oil analyses during a flax ripening

Ser No	Days after flowering	Weight of 1000 seeds mg	Moisture %	Dry matter %	Dry matter/1000 seeds mg	Oil %	Oil/dry matter %	Oil/1000 seeds mg	Protein %	Protein/dry matter %	Protein/1000 seeds mg	Lipolitic activity		Lipolitic activity/1000 seeds		FFA	J. V.	Fatty acids (spetroph-otmeth.) %				Fatty acids/1000 seeds mg				Glicerides (chromatographic method)			Monoglicerides and glicerol (chemical method) %			
												pH 5	pH 8	pH 5	pH 8			C^I	C^{II}	C^{III}	Saturated	C^I	C^{II}	C^{III}	Unsaturated	Tri- %	Di- %	Mono- %	1-mono-	2-mono-	Glicerol	Total mono-
I	14	12354	71.54	28.46	3416	5.18	18.16	640	5.06	16.69	625	—	—	—	—	1.24	162.5	3.7	13.7	42.7	35.4	24	88	274	227	88.5	4.5	7,0	0.29	—		—
II	21	12137	61.51	38.49	4673	13.99	36.36	1698	8.69	22.63	1055	7.65	10.27	35.74	48.00	0.92	182.6	17.8	10.8	53.8	13.3	302	183	913	226	88.3	5.4	6.3	0.26	2.80		3.06
III	28	11760	49.62	50.38	5864	21.16	42.01	2463	11.49	22.81	1354	8.10	4.38	48.08	26.04	0.66	188.5	17.4	10.4	56.4	11.5	429	256	1388	282	90.0	3.2	6.8	0.25	1.07		1.32
IV	35	11827	44.39	55.71	6620	22.90	41.10	2721	13.06	23.45	1544	5.65	2.90	37.25	19.10	0.53	191.2	13.6	12.2	57.3	12.5	370	332	1560	340	89.3	3,2	7.5	0.26	1.16	Traces	1.42
V	42	11303	39.39	60.61	6850	25.52	42.12	2885	14.81	24.43	1674	—	—	—	—	0.59	191.9	13. 6	12.0	57.7	12.3	397	347	1664	355	91.4	2.0	6.6	—	—		—
VI	49	9353	26.00	74.00	6920	30.98	41,86	2897	18.13	24.44	1696	1.15	1.49	8.00	10.38	0.35	193.0	15.1	12.1	57.5	10.9	437	352	1666	316	90.9	2.2	6.9	0.12	0.92		1.04

Results of linseed and linseed oil analyses differend varieties comming form experimental plots

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Table 6

Ser No	Variety	Grown in	Weight of 1000 seeds g	Dry matter/ 1000 seeds g	Moisture %	Dry matter %	Oil in dry matter %	Oil / 1000 seeds g	Protein in dry matter %	Protein/ 1000 seeds g	I.V.	Unsaturated fatty acids %			Unsaturated fatty acids /1000 seeds mg		
												C^{I}	C^{II}	C^{III}	C^{I}	C^{II}	C^{III}
1.	Kotowiecki	Olsztyn	7.095	6.551	7.65	92.36	40.85	2.676	22.47	1.472	183.0	22.7	13.3	50.5	606	355	1 346
		Giby	6.022	5.538	8.04	91.96	41.92	2.322	21.65	1.199	179.6	21.3	13.0	50.0	494	302	1 162
		Rzeszów	6.458	5.917	8.38	91.62	40.57	2.401	23.98	1.419	179.9	21.2	12.7	50.4	491	294	1 170
2.	LCSD=200	Olsztyn	8.200	7.630	6.95	93.06	40.56	3.092	24.21	1.847	189.6	23.1	12.3	53.5	715	382	1 654
		Giby	7.247	6.726	7.20	92.80	41.16	2.769	25.76	1.733	190.1	23.3	11.1	54.4	644	308	1 507
		Rzeszów	7.341	6.787	7.55	92.45	39.05	2.650	23.05	1.564	180.2	27.2	9.6	50.6	720	253	1 341
3.	LCSD=207	Olsztyn	5.874	5.365	8.67	91.33	38.47	2.058	25.96	1.393	192.4	18.9	12.4	55.7	389	255	1 146
		Giby	5.043	4.624	8.30	91.70	36.28	1.678	23.21	1.073	195.3	19.4	11.0	57.7	326	184	968
		Rzeszów	5.622	5.139	8.60	91.40	33.85	1.740	25.10	1.290	190.4	22.7	10.7	55.0	395	187	957
4.	LCSD=210	Olsztyn	5.817	5.380	7.54	92.47	35.94	1.934	27.29	1.468	188.0	25.6	11.4	52.7	495	220	1 020
		Giby	5.037	4.618	8.31	91.69	35.19	1.625	25.77	1.190	188.4	23.4	10.2	54.4	379	165	884
		Rzeszów	5.429	4.990	8.08	91.92	34.89	1.741	27.71	1.383	182.7	29.6	7.7	52.0	515	134	904
5.	Swadzimski	Olsztyn	5.667	5.254	7.28	92.73	35.57	1.870	27.08	1.423	196.4	22.8	11.4	56.8	427	212	1 060
		Giby	4.937	4.542	8.00	92.00	32.48	1.476	24.39	1.108	196.7	26.7	10.6	54.6	394	156	806
		Rzeszów	5.714	5.227	8.53	91.47	33.08	1.729	25.76	1.346	192.7	20.6	12.4	56.9	357	214	984
6.	Lazur	Olsztyn	5.581	5.121	8.24	91.76	35.49	1.817	26.03	1.333	192.8	21.8	12.3	55.2	396	223	1 002
		Giby	5.058	4.649	8.08	91.92	36.30	1.688	23.08	1.073	192.1	22.2	12.2	54.8	374	206	925
		Rzeszów	5.590	5.136	8.12	91.88	32.36	1.662	25.27	1.298	191.5	25.2	10.7	54.6	418	178	908

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Table 7

Results of linseed and linseed oil analyses

differend varieties comming from experimental plots

Grown in Giby

Ser No	Variety	Dry matter/ 1000 seeds g	Oil in dry matter %	Oil/1000 seeds g	Protein in dry matter %	Protein/ 1000 seeds g	I.V.	Unsaturated fatty acids %			Unsaturated fatty acids /1000 seeds mg		
								C'	C''	C'''	C'	C''	C'''
1.	Kotowiecki	5.538	41.92	2.322	21.65	1.199	179.6	21.3	13.0	50.0	494	302	1 162
2.	LCSD-200	6.726	41.16	2.769	25.76	1.733	190.1	23.3	11.1	54.4	644	308	1 507
3.	LCSD-207	4.624	36.28	1.678	23.21	1.073	195.3	19.4	11.1	57.7	326	184	968
4.	LCSD-210	4.618	35.19	1.625	25.77	1.190	188.4	23.4	10.2	54.4	379	165	884
5.	Swadzimski	4.542	32.48	1.476	24.39	1.108	196.7	26.7	10.6	54.6	394	156	806
6.	Lazur	4.649	36.30	1.688	23.08	1.073	192.1	22.2	12.2	54.8	374	206	925
	$\bar{X}$	5.116	37.22	1.926	23.98	1.229	190.4	22.7	11.4	54.3	435	220	1 042
	Amplitude	2.184	9.44	1.293	4.12	660	17.1	7.3	2.8	7.7	318	152	701
95%	Confidence interval	5.116 ± 874	37.22 ± 3.8	1.926 ± 517	23.98 ±1.65	1.229 ± 264	190.4 ± 6.8	22.7 ±2.9	11.4 ±1.1	54.3 ±3.1	435 ±3.1	220 ±56	1 042 ± 280

Table 8

Results of linseed and linseed oil analyses differend varieties comming from experimental plots

Grown in Olsztyn

Ser No	Variety	Dry matter/ 1000 seeds g	Oil in dry matter %	Oil/1000 seeds g	Protein in dry matter %	Protein/ 1000 seeds g	I.V.	Unsaturated fatty acids %			Unsaturated fatty acids/1000 seeds mg		
								C'	C''	C'''	C'	C''	C'''
1.	Kotowiecki	6.551	40.85	2.676	22.47	1.472	183.0	22.7	13.3	50.5	606	355	1 346
2.	LCSD-200	7.630	40.56	3.092	24.21	1.847	189.6	23.1	12.3	53.5	715	382	1 654
3.	LCSD-207	5.365	38.47	2.058	25.96	1.393	192.4	18.9	12.4	55.7	389	225	1 146
4.	LCSD-210	5.380	35.94	1.934	27.29	1.468	188.0	25.6	11.4	52.7	495	220	1 020
5.	Swadzimski	5.254	35.57	1.870	27.08	1.423	196.4	22.8	11.4	56.8	427	212	1 060
6.	Lazur	5.121	35.49	1.817	26.03	1.333	192.8	21.8	12.3	55.2	396	223	1 002
	$\bar{X}$	5.883	37.81	2.241	25.51	1.489	190.4	22.5	12.2	54.1	505	270	1 205
	Amplitude	2.509	5.36	1.275	4.82	514	13.4	6.7	1.9	6.3	326	170	652
95%	Confidence interval	5.883 ±1004	37.81 ±2.14	2.241 ± 510	25.51 ±1.93	1.489 ± 205	190.4 ± 5.4	22.5 ±2.7	12.2 ±0.8	54.1 ±2.5	505 ±130	270 ±68	1 205 ± 261

Table 9

Results of linseed and linseed oil analyses

differend varieties comming from experimental plots

Grown in Rzeszów

Ser No	Variety	Dry matter/ 1000 seeds g	Oil in dry matter %	Oil/ 1000 seeds g	Protein in dry matter %	Protein/ 1000 seeds g	I.V.	Unsaturated fatty acids %			Unsaturated fatty acids/1000 seeds mg		
								C'	C''	C'''	C'	C''	C'''
1.	Kotowiecki	5.917	40.57	2.401	23.98	1.419	179.9	21.2	12.7	50.4	491	294	1 170
2.	LCSD-200	6.787	39.05	2.650	23.05	1.564	180.2	27.2	9.6	50.6	720	253	1 341
3.	LCSD-207	5.139	33.85	1.740	25.10	1.290	190.4	22.7	10.7	55.0	395	187	957
4.	LCSD-210	4.990	34.89	1.741	27.71	1.383	182.7	29.6	7.7	51.9	515	134	904
5.	Swadzimski	5.227	33.08	1.729	25.76	1.346	192.7	20.6	12.4	56.9	357	214	986
6.	Lazur	5.136	32.36	1.662	25.27	1.298	191.5	25.2	10.7	54.6	418	178	908
	$\bar{X}$	5.533	35.63	1.987	25.15	1.383	186.2	24.4	10.6	53.2	483	210	1 044
	Amplitude	1.797	8.21	988	4.66	274	12.8	9.0	5.0	6.5	363	160	437
	95% Confidence interval	5.533 ± .719	35.63 ±3.28	1.987 ± 395	25.15 ±1.86	1.383 ± 110	186.2 ± 5.1	24.4 ±3.6	10.6 ±2.0	53.2 ±2.6	483 ±145	210 ±64	1 044 ± 175

Table 10

Results of linseed and linseed oil analyses

Variety Kotowiecki comming from pot - tests.

Ser No	Grown in	Weight of 1000 seeds mg	Moisture %	Dry matter %	Dry matter/ 1000 seeds mg	Oil %	Oil in dry matter %	Oil/ 1000 seeds mg	Protein %	Protein in dry matter %	Protein/ 1000 seeds mg	I.V.	Fatty acids %			Fatty acids/ 1000 seeds mg		
													C^{I}	C^{II}	C^{III}	C^{I}	C^{II}	C^{III}
1.	Giby	7898	6.53	93.47	7382	39.31	42.07	3105	22.25	23.80	1757	189.1	25.3	16.0	50.2	786	497	1559
2.	Szczecin	4972	6.19	93.81	4664	36.37	38.72	1808	21.03	22.42	1046	184.6	26.3	12.3	50.6	476	222	915
3.	Olsztyn	6773	6.56	93.44	6328	34.96	37.41	2368	23.94	25.62	1621	186.7	25.6	15.1	49.8	606	358	1179
4.	Bydgoszcz	4876	6.34	93.66	4567	33.66	35.93	1641	25.69	27.43	1253	180.7	26.6	11.3	49.8	437	185	817
5.	Puławy	5689	6.96	93.04	5293	31.38	33.73	1785	24.06	25.86	1369	173.4	33.5	11.4	44.8	598	203	800
6.	Wrocław	5982	6.82	93.18	5574	37.24	39.96	2228	22.94	24.62	1372	180.9	31.6	13.3	46.9	704	296	1045
7.	Rzeszów	6290	6.58	93.42	5877	34.79	37.23	2188	21.06	22.54	1325	176.0	27.9	12.9	46.6	610	282	1020
$\bar{X}$					5669	35.39	38.86	2160	23.00	24.61	1392	181.6	28.1	13.2	48.4	602	292	1048
Amplitude					2815	7.93	8.34	1464	4.66	5.01	711	15.7	8.2	4.7	5.8	349	312	759
95 % Confidence interval					5669 ±929	35.39 ±2.62	38.86 ±2.75	2160 ±483	23.00 ±1.54	24.61 ±1.65	1392 ±235	181.6 ± 5.2	28.1 ±2.7	13.2 ±1.6	48.4 ±1.9	602 ±115	292 ±103	1048 ±250

Table 11

Results of linseed and linseed oil analyses

Variety LCSD - 200 comming from pot - tests.

Ser No	Grown in	Weight of 1000 seeds mg	Moisture %	Dry matter %	Dry matter/ 1000 seeds mg	Oil %	Oil/ in dry matter %	Oil/ 1000 seeds mg	Protein %	Protein in dry matter %	Protein/ 1000 seeds mg	I.V.	Fatty acids %			Fatty acids/ 1000 seeds mg		
													C'	C''	C'''	C'	C''	C'''
1.	Giby	7362	6.44	93.56	6888	36.41	38.91	2681	22.97	24.55	1691	189.6	25.6	12.4	52.7	686	332	1413
2.	Szczecin	5741	6.32	93.68	5379	33.40	35.64	1918	24.81	26.48	1424	186.7	27.4	10.7	52.1	526	205	999
3.	Olsztyn	7633	6.95	93.05	7103	36.44	39.15	2782	23.09	24.81	1762	190.2	26.3	12.6	52.5	732	351	1461
4.	Bydgoszcz	6590	6.02	93.98	6193	35.08	37.32	2312	25.72	27.37	1695	185.3	29.2	9.6	51.8	675	222	1198
5.	Puławy	6860	6.37	93.63	6423	29.48	31.49	2022	24.03	25.66	1648	175.5	30.0	9.9	47.7	607	200	964
6.	Wrocław	6837	6.19	93.81	6414	34.93	37.23	2388	24.53	26.15	1677	181.2	26.5	13.4	48.7	633	320	1163
7.	Rzeszów	6451	6.92	93.08	6005	32.34	34.74	2086	18.34	19.70	1183	185.2	29.5	12.0	50.0	615	250	1043
$\bar{X}$					6344	34.01	36.35	2313	23.36	24.96	1583	184.8	27.8	11.5	50.9	639	269	1177
Amplitude					1724	6.96	7.66	865	7.38	7.67	579	14.7	4.4	3.8	5.0	206	151	497
95 % Confidence interval					6344 ±569	34.01 ±2.30	36.35 ±2.53	2313 ±285	23.36 ±2.44	24.96 ±2.53	1583 ±191	184.8 ± 4.9	27.8 ±1.5	11.5 ±1.3	50.9 ±1.7	639 ±68	269 ±50	1177 ±164

Table 12

Results of linseed and linseed oil analyses

Variety LCSD - 207 comming from pot - tests.

Ser No	Grown in	Weight of 1000 seeds mg	Moisture %	Dry matter %	Dry matter/ 1000 seeds mg	Oil %	Oil in dry matter %	Oil/ 1000 seeds mg	Protein %	Protein in dry matter %	Protein/ 1000 seeds mg	I.V.	Fatty acids %			Fatty acids/ 1000 seeds mg		
													C'	C''	C'''	C'	C''	C'''
1.	Giby	5296	6.93	93.07	4929	28.57	30.70	1513	26.75	28.74	1417	193.3	25.9	12.4	53.9	392	188	816
2.	Szczecin	4583	7.12	92.88	4257	29.81	32.09	1366	27.09	29.17	1242	191.9	26.9	10.7	54.2	367	146	740
3.	Olsztyn	5427	7.41	92.59	5025	29.99	32.41	1627	25.28	27.30	1372	197.3	23.7	11.5	56.7	386	187	923
4.	Bydgoszcz	4225	6.19	93.81	3964	28.82	30.72	1218	26.91	28.68	1137	191.7	26.8	11.1	53.9	326	135	657
5.	Puławy	4872	7.05	92.95	4528	23.37	25.15	1139	26.13	28.11	1273	185.9	29.8	12.6	49.8	339	144	567
6.	Wrocław	4730	6.72	93.28	4412	28.96	31.04	1370	26.72	28.64	1264	191.4	25.1	13.9	52.5	344	190	719
7.	Rzeszów	4475	7.31	92.69	4148	28.63	30.89	1281	20.28	21.88	908	189.4	20.9	11.4	54.8	268	146	702
$\bar{X}$					4466	28.31	30.42	1359	25.59	27.50	1230	191.6	25.6	11.9	53.7	337	162	718
Amplitude					1062	6.62	7.26	488	6.81	7.29	509	7.4	8.9	3.2	6.9	124	55	356
95 % Confidence interval					4466 ±350	28.31 ±2.18	30.42 ±2.4	1359 ±195	25.59 ±2.25	27.50 ±2.4	1230 ±168	191.6 ± 2.4	25.6 ±2.9	11.9 ±1.1	53.7 ±2.3	337 ±41	162 ±18	718 ±117

Table 13

Results of linseed and linseed oil analyses

Variety LCSD - 210 comming from pot - tests.

Ser No	Grown in	Weight of 1000 seeds mg	Moisture %	Dry matter %	Dry matter/ 1000 seeds mg	Oil %	Oil in dry matter %	Oil/ 1000 seeds mg	Protein %	Protein in dry matter %	Protein/ 1000 seeds mg	I.V.	Fatty acids %			Fatty acids/ 100 seeds mg		
													C^{I}	C^{II}	C^{III}	C^{I}	C^{II}	C^{III}
1.	Giby	5140	6.91	93.09	4785	29.21	31.38	1502	26.50	28.47	1362	186.9	29.08	13.8	49.6	437	207	745
2.	Szczecin	4455	6.97	93.03	4144	30.25	32.50	1348	27.65	29.72	1232	182.7	25.58	12.9	49.6	345	174	669
3.	Olsztyn	5592	6.87	93.13	5208	27.63	29.66	1545	26.28	28.22	1470	189.6	29.60	12.7	51.2	457	196	791
4.	Bydgoszcz	4362	6.15	93.85	4093	30.55	32.54	1332	27.66	29.47	1206	184.0	32.42	11.3	49.1	432	151	654
5.	Puławy	4896	7.08	92.92	4549	25.76	27.71	1261	27.84	29.96	1363	180.3	30.38	12.4	47.7	383	156	601
6.	Wrocław	4352	6.56	93.44	4067	29.80	31.89	1297	27.34	29.26	1190	184.1	27.28	13.6	49.3	354	176	639
7.	Rzeszów	4835	7.13	92.87	4491	31.27	33.66	1512	23.50	25.30	1136	181.2	26.74	11.7	49.6	404	177	750
$\bar{X}$					4477	29.21	31.33	1400	26.68	28.63	1280	184.1	28.7	12.6	49.4	402	177	693
Amplitude					1141	5.51	5.95	284	4.34	3.34	334	8.4	6.8	2.5	3.5	112	56	190
95 % Confidence interval					4477 ±377	29.21 ±1.82	31.33 ±1.96	1400 ± 94	26.68 ±1.43	28.63 ±1.10	1280 ±110	184.1 ± 2.8	28.7 ±2.2	12.6 ±0.8	49.4 ±1.2	402 ±37	177 ±18	693 ±63

Table 14

Results of linseed and linseed oil analyses

Variety Swadzimski comming from pot - tests.

Ser No	Grown in	Weight of 1000 seeds mg	Moisture %	Dry matter %	Dry matter/ 1000 seeds mg	Oil %	Oil in dry matter %	Oil/ 1000 seeds mg	Protein %	Protein in dry matter %	Protein/ 1000 seeds mg	I.V.	Fatty acids %			Fatty acids/ 1000 seeds mg		
													C^{I}	C^{II}	C^{III}	C^{I}	C^{II}	C^{III}
1.	Giby	5194	7.08	92.92	4826	31.07	33.43	1614	25.81	27.78	1341	193.3	25.3	12.0	54.4	408	194	878
2.	Szczecin	4823	6.38	93.62	4516	30.11	32.16	1452	26.38	28.18	1272	193.4	28.9	10.4	54.3	420	151	788
3.	Olsztyn	5650	6.79	93.21	5266	27.68	29.69	1564	26.31	28.23	1487	192.8	28.2	13.4	52.3	441	210	818
4.	Puławy	5035	7.01	92.99	4682	22.84	24.56	1150	26.56	28.56	1337	190.4	28.9	11.2	52.7	332	129	606
5.	Wrocław	4683	6.47	93.53	4380	29.92	31.99	1401	26.65	28.49	1248	191.7	27.9	10.6	53.8	391	149	754
6.	Rzeszów	4607	7.16	92.84	4277	29.14	31.38	1342	20.15	21.70	928	193.3	26.3	10.9	54.8	353	146	735
$\bar{X}$					4658	28.46	30.54	1421	25.31	27.15	1269	192,5	27.6	11.4	53.7	391	163	763
Amplitude					989	8.23	8.87	464	6.50	6.80	559	3.0	3.6	3.0	2.5	109	81	272
95 % Confidence interval					4658 ±396	28.46 ±3.29	30.54 ±3.55	1421 ±186	25.31 ±2.60	27.15 ±2.72	1269 ±224	192.5 ± 1.2	27.6 ±1.40	11.4 ±1.2	53.7 ±1.0	391 ±44	163 ±32	763 ±109

Table 15

Results of linseed and linseed oil analyses

Variety Lazur comming form pot - tests.

Ser No	Grown in	Weight of 1000 seeds mg	Moisture %	Dry matter %	Dry matter/ 1000 seeds mg	Oil %	Oil in dry matter %	Oil/ 1000 seeds mg	Protein %	Protein in dry matter %	Protein/ 1000 seds mg	I.V.	Fatty acids %			Fatty acids/ 1000 seeds mg		
													C'	C''	C'''	C'	C''	C'''
1.	Giby	5113	7.01	92.99	4755	31.95	34.35	1634	26.05	27.99	1331	190.6	26.0	12.39	52.90	425	202	864
2.	Szczecin	4708	6.49	93.51	4402	31.43	33.61	1480	25.75	27.54	1212	190.3	28.9	11.65	52.33	428	172	774
3.	Olsztyn	5386	6.81	93.19	5020	28.56	30.64	1538	26.13	28.04	1407	190.5	27.1	13.32	51.94	417	205	799
4.	Puławy	4958	6.90	93.10	4616	24.94	26.78	1236	27.44	29.47	1360	189.8	28.6	10.40	53.09	353	129	656
5.	Wrocław	4545	6.84	93.16	4234	30.09	32.25	1367	27.28	29.28	1239	191.1	31.3	12.01	51.56	428	164	705
6.	Rzeszów	4654	6.78	93.22	4338	30.95	33.19	1440	20.78	22.29	967	190.9	27.8	13.34	51.75	400	192	745
$\bar{X}$					4561	29.65	31.80	1449	25.57	27.43	1253	190.5	28.3	12.2	52.3	408	177	757
Amplitude					786	7.01	7.57	398	6.66	7.18	440	1.3	5.3	2.9	1.5	75	76	208
95 % Confidence interval					4561 ±314	29.65 ±2.80	31.80 ±3.03	1449 ±159	25.57 ±2.66	27.43 ±2.9	1253 ±176	190.5 ±0.52	28.3 ±2.1	12.2 ±1.2	52.3 ±0.6	408 ±30	177 ±30	757 ±83

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