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EVALUATION OF RAW MATERIAL FOR MUSTARD PRODUCTION IN MIDDLE-EAST POLAND CONDITIONS

Summary. Physical and chemical analyses were carried out in mustard samples collected from the field experiment in 1995-1997 in the middle-eastern Poland on weak loamy sand soil. The experimental factors were two mustard cultivars: 'Nakielska' and 'Małopolska'. The following features were determined: moisture – by method of drying, oil content – by means of Soxlet, content of insoluble in 10% HCl ash – by means of weight, acidic number of fat – by means of titration, Lea number – by means of titration in the seed after oil was partly removed. These features of mustard flour quality (except acidic number) appeared to be right with PN-A--86964:2002. Most of features depended on cultivars. 'Nakielska' cultivar (white mustard) appeared to be more stable, in respect of water content, acidic number and Lea number, than 'Małopolska' (Indian mustard). Higher rainfalls during study years led to high content of free fatty acids and peroxides. Thus mustard seeds should be dried, or quickly directed for production after harvesting to avoid decreasing of fat quality.

Key words: white mustard, Indian mustard, chemical composition, cultivars

Introduction

A mustard is a condiment made from mustard seeds, water, salt, sugar, vinegar and without or with other taste-flavour additives permitted by local law (PN-A-86964: 2002). The quality of a final product depends mainly on the raw material quality, i.e. mustard seeds as well as conditions the technological process is performed in. The raw material should be of a proper colour of matured seeds, gloss, natural flavour, proper humidity and purity (PN-A-86962:1997). Glucosinolans content in mustard seeds is a very important determinant of their quality, because they make the final product spicy. Mustard consistency is determined by contents of gelating substances in seeds. Seeds of white, black and Indian mustard contain large amounts of oil that remains after mill cake extrusion, but it cannot be used in foodstuff industry due to high level of erucic

acid. Research upon achievement of new mustard genotypes with decreased glucosinolans and erucic acid contents is being performed. It would allow applying the plant as spring oil and fodder crop used in animal farming. Because of the wide range of available mustard seeds on markets, there is a need to control the raw material, semiproducts and final product. Thus, examinations of the quality of de-oiled powdered mustard seeds ('Nakielska' cv. – white, and 'Małopolska' cv. – Indian mustard) were undertaken in order to find out if they can ensure a high quality of mustard produced in accordance to norms and European standards.

Material and methods

Study was based on a field experiment conducted in middle-eastern Poland in 1995--1997 on slightly acidic soil with weak loamy sand composition. The soil was characterised by a very high content of available potassium, high – phosphorus, zinc, medium – manganese, and low – magnesium and copper. Two mustard cultivars were experimental factors: 'Nakielska' cv. – white and 'Małopolska' cv. – Indian mustard. The experiment was performed by means of randomised blocks in three replications. Mineral fertilization at a constant level was applied: 80 kg N, 35 kg P, 52 kg K per 1 ha. Seeds of elite class were the seeding material. Mustard was cultivated in accordance to the latest agrotechnical recommendations. Seeds were harvested after maturation. Determinations of raw material for mustard production were made in Vinegar and Mustard Works in Parczew. Before production, 1-5 g samples of de-oiled seeds were taken for physical and chemical determination. All analyses were carried out in three replications. The following parameters were determined in de-oiled mustard seeds: humidity – by means of drying method, fat content – Soxhlet's method, ash insoluble in 10% HCl – weight method, fat acidic number – titrimetric method, Lea number of extracted fat – titrimetric method using sodium thiosulfate. Statistical data working out was performed applying variance analysis. Significance of variability sources was checked using Fisher-Snedecor's test. Difference significance was estimated with Tukey's test. Moreover, variability coefficients for every trait were calculated according to formula: $V = s/\bar{x} \cdot 100\%$, where: s – standard deviation, $\bar{x}$ – arithmetic mean. The weather conditions during the experiment varied, which is illustrated on Figure 1.

Results

Humidity of mustard seed samples was different for various species (Table 1). Powdered and de-oiled white mustard seeds ('Nakielska' cv.) was characterized by significantly higher humidity than those of Indian mustard ('Małopolska' cv.). Study years did not differentiate the water contents in mustard seeds (Table 2). However, humidity of both cultivars seed samples depended on their reaction towards weather conditions during experiment (Fig. 2). White mustard cultivar ('Nakielska') was the least wet in dry 1995, and the most humid in moderate 1996. That latter year, seeds of Indian mustard ('Małopolska') contained the lowest water content, and the highest in 1995. Instead, both cultivars did not differ from each other referring to water content in 1995.

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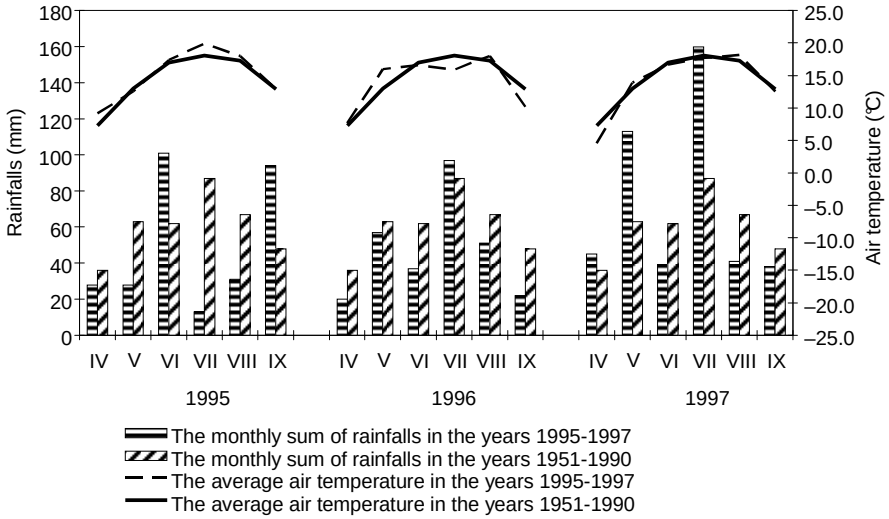

Fig. 1. Rainfalls and air temperature during mustard vegetation period in the years 1995--1997 according to Institute for Meteorology and Water Management at Włodawa
Rys. 1. Opady i temperatura powietrza w okresie wegetacji gorczycy w latach 1995-1997 według stacji meteorologicznej Instytut Meteorologii i Gospodarki Wodnej we Włodawie

Table 1. Influence of cultivar on mustard flour quality (mean for years 1995-1997)
Tabela 1. Wpływ odmiany na jakość mączki gorczycy (średnia z lat 1995-1997)

Cultivar	Content of water (g/kg)	Content of ash (g/kg)	Content of fat (g/kg)	Acidic number	Lea number
'Nakielska' (white mustard)	96.8	0.17	145.8	5.08	1.28
'Małopolska' (Indian mustard)	78.8	0.19	176.6	6.17	1.66
$LSD_{0.05}$	4.4	n	8.1	0.28	0.07

n – not significant at $\alpha \leq 0.05$.

Ash content in mustard seeds did not significantly depend on cultivar traits, although more susceptibility to accumulate ashable components was observed for Indian ('Małopolska' cv.) than white mustard ('Nakielska' cv.) (Table 1). Study years significantly differentiated the mineral components contents in seeds. The highest ash amounts were recorded in extremely dry 1995, the lowest in moderate 1996 (Table 2). Both tested mustard cultivars reacted to weather conditions during experiment in similar way. 'Nakielska' cv. accumulated the highest levels of ash in 1995, the lowest in 1996. 'Małopolska' cv. behaved the same manner. The largest difference relating to insoluble ash content between tested cultivars was observed in 1995, the smallest in extremely wet 1997 (Fig. 3).

Table 2. Influence of year of cultivation on mustard flour quality (mean for two cultivars)
Tabela 2. Wpływ roku uprawy na jakość mączki gorczycy (średnia z dwu odmian)

Year	Content of water (g/kg)	Content of ash (g/kg)	Content of fat (g/kg)	Acidic number	Lea number
1995	88.7	0.25	159.2	2.38	0.54
1996	87.0	0.11	163.2	8.87	2.41
1997	87.7	0.19	161.9	5.63	1.48
Mean	87.8	0.18	161.2	5.62	1.47
$LSD_{0.05}$	n	0.01	12.1	0.42	0.11

n – not significant at $\alpha \leq 0.05$.

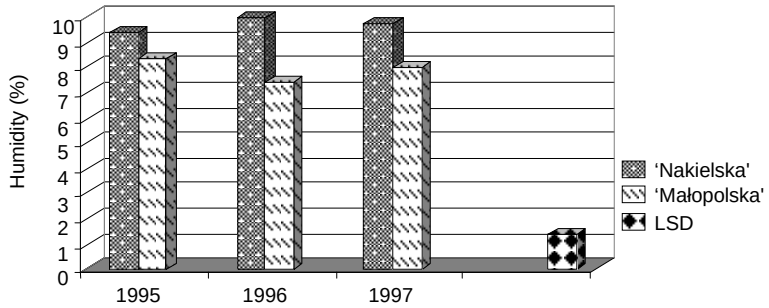

Fig. 2. The influence of years and cultivars on the mustard flour humidity
Rys. 2. Wpływ lat i odmian na wilgotność mączki gorczycy

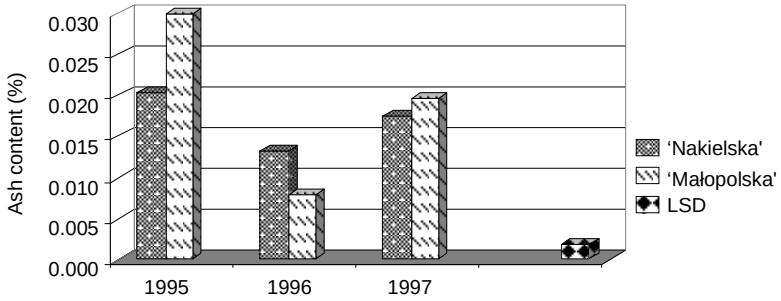

Fig. 3. The influence of years and cultivars on the ash content of mustard flour
Rys. 3. Wpływ lat i odmian na zawartość popiołu w mączce gorczycy

Fat content in tested powder made of mustard seeds depended on cultivar traits. Seeds of 'Małopolska' cv. were characterised by a significantly higher fat content than

those of ‘Nakielska’ cv. (Table 1). The component content varied depending on weather conditions during experiment. The poorest fat accumulation was observed in dry 1995, the richest in moderate 1996 (Table 2). Fat content in mustard seeds appeared to depend on cultivar reaction towards weather conditions in study years. ‘Nakielska’ cv. was distinguished by the lowest fat level in 1995, the highest in 1996. ‘Małopolska’ cv. was characterized by the highest fat amount in dry 1995, the lowest in moderate 1996. The lowest difference of fat content between cultivars was found in moderate 1996, the highest in dry 1995 (Fig. 4).

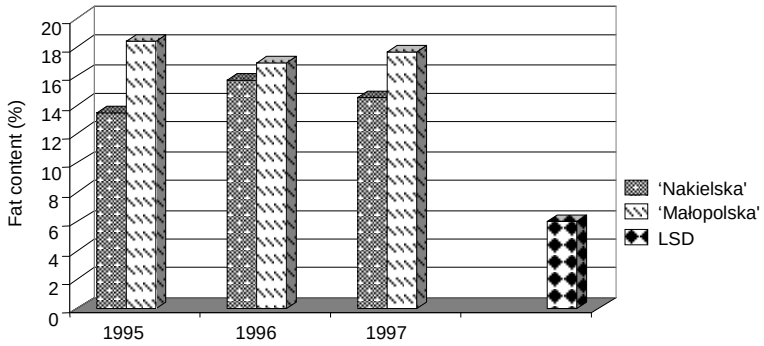

Fig. 4. The influence of years and cultivars on the fat content of mustard flour
Rys. 4. Wpływ lat i odmian na zawartość tłuszczu w mączce gorczycy

Average value of the fat acidic number was 5.62. ‘Małopolska’ cv. was characterised by higher acidic number than ‘Nakielska’ cv. (Table 1). However, study years exerted the most important influence on that number value. The lowest acidic number was observed in dry 1995, the highest in moderate 1996; in extremely wet 1997, the value was at medium level (Table 2). Both cultivars reacted in similar way to weather conditions during the experiment. The highest fat acidic number was found in 1996, and the lowest in dry 1995 for both cultivars. The difference of fat acidic number between cultivars was the highest in 1996; other years, that difference appeared to be statistically insignificant (Fig. 5).

Peroxide content in powdered mustard seeds was determined by cultivar traits. Lea number was higher for ‘Małopolska’ cv. than in the case of ‘Nakielska’ cv. (Table 1). Study years also significantly modified tested parameter. Its highest value was observed in moderate 1996, and the lowest in dry 1995 (Table 2). Tested mustard seeds cultivars reacted to weather conditions during the experiment in a different manner (Fig. 6). The largest difference of Lea number occurred in moderate 1996; in dry 1995, the difference between cultivars was insignificant.

Among the tested parameters, water content in seeds appeared to be the most stable (V = 4.13%), Lea number – the least (V = 53.59%) (Table 3). ‘Nakielska’ cv. was more stable relating to majority of tested traits, including seed humidity, ash content, acidic number and Lea number. Indian mustard cultivar (‘Małopolska’) was characterised by a higher stability of fat accumulation than ‘Nakielska’ cv.

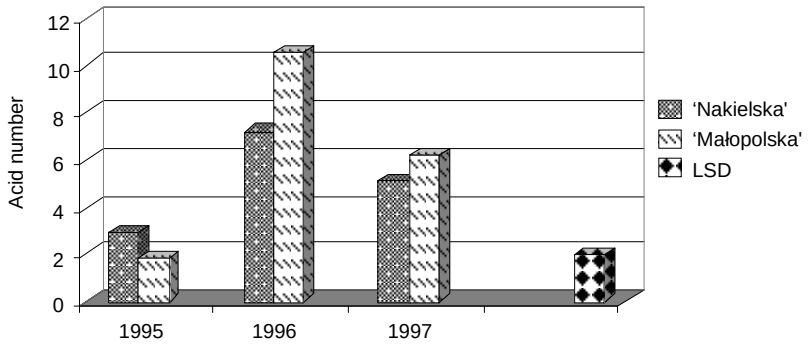

Fig. 5. The influence of years and cultivars on the acidic number in mustard flour
Rys. 5. Wpływ lat i odmian na liczbę kwasową w mączce gorczycy

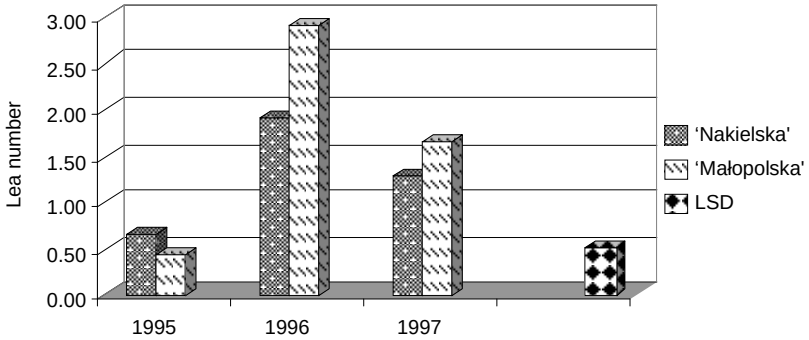

Fig. 6. The influence of years and cultivars on the Lea number in mustard flour
Rys. 6. Wpływ lat i odmian na liczbę Lea w mączce gorczycy

Table 3. Mean arithmetic values of mustards features ($\bar{x}$) and their variability coefficients (V)
Tabela 3. Średnie arytmetyczne wartości cech gorczyc ($\bar{x}$) oraz współczynniki ich zmienności (V)

Cultivar	Content of water (g/kg)		Content of ash (g/kg)		Content of fat (g/kg)		Acidic number		Lea number	
	$\bar{x}$	V	$\bar{x}$	V	$\bar{x}$	V	$\bar{x}$	V	$\bar{x}$	V
'Nakielska' (white mustard)	96.8	0.96	0.17	6.12	145.8	2.21	5.08	12.19	1.28	14.36
'Małopolska' (Indian mustard)	78.8	1.79	0.19	16.56	176.6	1.18	6.17	20.36	1.66	21.36
Mean	87.8	1.38	0.18	11.34	161.2	1.70	5.62	16.28	1.47	17.86
$LSD_{0.05}$	4.4	–	n	–	8.1	–	0.28	–	0.07	–

n – not significant at $\alpha \leq 0.05$.

Discussion

The cultivar properties differentiated most of the tested traits of mustard seeds. These changes related to a higher fat content and ash in Indian as compared to white mustard seeds, but lower amount of water. However, white mustard ('Nakielska' cv.) was characterised by lower level of fat acidic number and Lea number than Indian mustard ('Małopolska' cv.). Study results achieved by MURAWA et AL. (2001, 2003) also revealed the differences of fat accumulation between cultivars. 'Nakielska' cv. was distinguished by higher fat content than 'Borowska' cv. Own study showed that Indian mustard ('Małopolska' cv.) was characterised by a better fat stability in seeds than white cultivar ('Nakielska'). However, the former revealed higher variability of traits in question, which probably resulted from its higher susceptibility to unfavourable weather conditions during vegetation period, namely drought. Variability coefficients are a measure of achieved results scatter, which makes it possible to compare various traits to one another. In opinion of KORONACKI and MIELNICZUK (2004), the lower variability coefficient, the more stable a given trait. DECLERCQ (1999, 2005) observed that white mustard was characterised by lower fat and higher protein content in relation to Indian mustard, and oil produced from white mustard seeds contained more oleinic (C18:1) and erucic (C22:1), but less linoleic (C18:2) acid than Indian mustard seeds. Own research indicates that the study years significantly modified the traits of mustard seed powder such as: ash and fat contents as well as fat acidic number and Lea number. DECLERCQ (1999, 2005) confirmed the influence of weather conditions on chemical composition of mustard seeds. WOODS and DOWNEY (1980), RANEY and RAKOW (1999) observed that cultivar properties were considerably modified by environmental conditions. MURAWA et AL. (2003) found that 'Nakielska' cv. accumulated more fat in seeds in a wet year, and 'Borowska' cv. in a dry year. The percentage of fatty acids due to thermal and humidity conditions was different in both mustard cultivars as well. In their opinion, in wet years, 'Borowska' cv. was characterised by a higher share of saturated and 'Nakielska' cv. – monounsaturated fatty acids.

Studies of CUI et AL. (1993), HEMINGWAY (1995), BROWN et AL. (1999), ESKIN et AL. (1999), KAUSHIK and AGNIHOTRI (2000), indicate a significant influence of chemical composition of mustard seeds as a basic raw material for mustard production, on final product quality. Proper thermal conditions not exceeding 52°C should be ensured during seed processing (drying, de-oiling) and mustard production, because overheating causes the inactivation of myrosinase, which makes it impossible to form volatile bitter oils (HEMINGWAY 1995, SAWICKA and KOTIUK 2007).

Conclusions

1. Seeds of both mustard cultivars differed with water and fat contents as well as acidic and Lea number. Variability coefficients for majority of the tested parameters indicated that white ('Nakielska' cv.) was more stable than Indian mustard ('Małopolska' cv.).

2. Tested parameters of mustard seed quality were in accordance to PN-A-86964: 2002, except for acidic number.

3. Values of acidic and Lea numbers in seeds as well as fat content were the lowest in a dry year, but they were within obligatory norms.

4. During mustard vegetation, more free fatty acids and peroxides were found in fat in seasons with elevated rainfall sum than in dry years. Therefore, the raw material achieved under such conditions should be dried in order to protect against fat qualitative traits worsening.

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OCENA SUROWCA DO PRODUKCJI MUSZTARDY W WARUNKACH ŚRODKOWOWSCHODNIEJ POLSKI

Streszczenie. Wyniki badań oparto na doświadczeniu polowym przeprowadzonym w środkowowschodniej Polsce w latach 1995-1997, na glebie o składzie piasków słabo gliniastych lekkich. Badaniami objęto dwie odmiany gorczyc: 'Nakielską' (gorczyca biała) i 'Małopolską' (gorczyca sarepska). W doświadczeniu stosowano nawożenie mineralne na stałym poziomie: 80 kg azotu, 35 kg fosforu, 52 kg potasu na 1 ha. Materiałem siewnym były nasiona w klasie elity. Gorczyce uprawiano według najnowszych zaleceń agrotechnicznych. Zbiór był wykonywany po dojrzeniu nasion. Do oznaczeń chemicznych pobrano próbki odolejonych nasion po 1-5 g. Badania wykonano w trzech powtórzeniach. W odolejonych nasionach gorczycy oznaczano: wilgotność – metodą suszenia, zawartość tłuszczu – metodą Soxleta, zawartość popiołu nierozpuszczalnego w 10--procentowym HCl – metodą wagową, liczbę kwasową tłuszczu – metodą miareczkową, liczbę Lea wyekstrahowanego tłuszczu – metodą miareczkową z tiosiarczanem sodowym. Statystyczne opracowanie wyników badań wykonano za pomocą analizy wariancji. Istotność źródeł zmienności sprawdzono testem Fishera-Snedecora. Istotność różnic oceniono testem Tukeya. Badane parametry jakości obu odmian gorczyc, poza liczbą kwasową, były zgodne z PN-A-86964:2002. Właściwości odmianowe różnicowały większość badanych cech. Odmiana 'Nakielska' okazała się bardziej stabilna, pod względem zawartości wody, liczby kwasowej i liczby Lea, niż odmiana 'Małopolska'. Zwiększonym opadom towarzyszył wzrost ilości wolnych kwasów tłuszczowych i nadtlenków w tłuszczu, toteż surowiec uzyskany w latach wilgotnych powinien być jak najszybciej dosuszony bądź w jak najkrótszym czasie po zbiorze skierowany do produkcji, aby zapobiec pogorszeniu cech jakościowych tłuszczu.

Słowa kluczowe: gorczyca biała, gorczyca sarepska, skład chemiczny, odmiany

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