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EVALUATION OF HEALTH SAFETY OF MUSTARDS IN THE ASPECT OF OBLIGATORY NORMS

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Abstract. The results were based on mustards produced in the Vinegar and Mustard Factory in Parczew during the years 1995-1998; major components were Nakielska (*Sinapis alba*) and Małopolska (*Brassica juncea*). Four items were the experimental factors (stołowa – dainty mustard, sarepska – popular mustard, kremska – popular mustard, papric – popular mustard). There 1-5 g of mustard from 3 repetitions of every combination were taken for laboratory analyses. The following were determined: dry matter content – by gravimetric method, total acidity – by means of titration, chloride content – by means of Mohr, organoleptic valuation (taste, flavour, consistency, colour and appearance) by 9°scale. They were statistically elaborated using variance analysis. Significance of variability sources was calculated using Fischer-Snedecor's "F" test. Tukey's test was helpful to estimate the difference significance. They were features of four mustards quality appeared to be with PN-A-86964 [2002]. Contents of NaCl turned out in years of research changeable in mustards, that show in the recipe of the product a high liability of the component. In the following way it is possible to range the analysed kinds in respect of the stability: stolowa dainity > popular papric > popular sarepska > popular kremska. The biggest changes in dry mass contents, and smallest stability of acidity characterized mustards papric and sarepska. The contents of dry mass turned out among comparable features stable – chemical in mustards, least – concentrate NaCl. Taste turned out to be stable from the organoleptical features of mustards, however, least colour and appearance. Most stable, in respect of the researched features – chemical and organoleptical – turned out dainty and the least sarepska mustard.

Key words: mustards, kinds, quality

INTRODUCTION

First mustard recipes appeared in 13-14th centuries as *senapium* [Lloyd 1911]. Later, both recipes and production technology were modified depending on consumer's tastes in a given area [Hemingway 1995, Man and Weir 1988]. According to Polish

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Norm PN-A-86964 [2002], mustard is a spice produced from mustard seeds, water, salt, sugar, vinegar and with or without other taste and flavour components permissible by local law. Depending on the refinement of mustard seeds and taste and flavour components added, three mustard types are distinguished: popular, dainty, and special. Types and proportions of used materials, spices and taste and flavour components make another division: dainty, sarepska, kremska, horse-radish, paprika, tomato, honey, garlic, French (Dijon), etc. A final product should fulfill given organoleptic and physicochemical requirements according to PN-A-86964 [2002]. Moreover, product should not contain substances being a potential threat to consumers. The producer is responsible for food safety and should take care of it basing on HACCP system rules according to EU Decree No 852/2004 of EU Parliament and European Board (Dz.U. no 139 from April 30, 2004). The system is also aimed to define methods for threats reduction (Dz.U. no 31, pos. 265). A threat, as Decree defines, is a biological, chemical or physical component of food or existing during its production that may be dangerous for human health [Kołożyn-Krajewska and Sikora 1999, Turlejska 2003]. Raw materials, semi-products and final products control guarantees the food safety. Therefore, undertaking the quality assessment of mustards produced in Poland to be safe for consumers is necessary.

MATERIAL AND METHODS

Mustard analyses were carried out in 1995-1998 in Vinegar and Mustard Production Works in Parczew. Four mustard types were experimental factors: dainty, sarepska, kremska and paprika. Following parameters were assessed: colour and structure, consistence, scent and taste. Physicochemical requirements for mustard included: dry matter content, total acidity recalculated onto acetic acid, and sodium chloride content. Dry matter was determined applying gravimetric method (PN-90/A-75101/03), total acidity – titrimetric method (PN-90/A-75101/04), sodium chloride content – Mohr's method

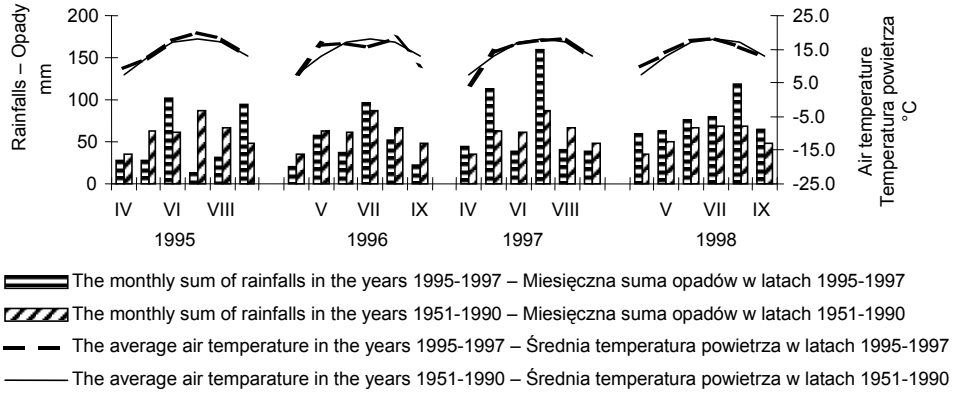

Fig. 1. Rainfalls and air temperature during mustard vegetation period in the years 1995-1998, acc. to IMGW at Włodawa
Rys. 1. Opady i temperatura powietrza w okresie wegetacji gorczycy w latach 1995-1998 w stacji meteorologicznej we Włodawie

(PN-90/A-75101/10), organoleptic traits (taste, scent, consistence, colour, and structure) – in 9° grade according to PN-ISO 4121 [1998].

Statistical processing of achieved results was performed using variance analysis. Significance of variability sources was checked using Fisher-Snedecor's test. Tukey's test was used to determine the difference significance. Variability coefficients were calculated according to the formula: where: s – standard deviation, x – arithmetic mean [Trętowski and Wójcik 1988].

Temperature and rainfall distributions in analysed years varied, which is presented in Figure 1.

RESULTS

Dry matter content in the tested mustards was 23.64%, on average, and it was within permissible norm for that type of products [PN-A-86964 2002]. The trait value was mainly determined by mustard type (Table 1). Kremska mustard was characterized by the highest content of dry matter, sarepska – the lowest. Significant differences of that trait also occurred between kremska vs. sarepska and paprika as well as dainty and sarepska. Dainty with kremska and sarepska with paprika appeared to be uniform referring to the discussed trait. The dry matter content appeared to be the most stable in the case of dainty mustard, and less stable at paprika one (Table 1). The mustard cultivation conditions in the study years did not affect the dry matter contents in the analysed products (Table 3). However, the trait values depended on interaction of mustard type and weather conditions in mustard cultivation years (Fig. 2). Both in dry years (1995-1996)

Table 1. Value of mustard feature and variability coefficients
Tabela 1. Wartości cech musztard oraz współczynniki ich zmienności

Kind of mustards Rodzaj musztard	Mustards feature – Cechy musztard					
	content of dry matter zawartość suchej masy		acidity kwasowość		content of NaCl zawartość NaCl	
	%	V	%	V	%	V
Delikatesowa − stołowa	24.26	1.06	2.43	6.08	2.46	2.06
Popularna sarepska	22.19	2.81	2.16	2.32	2.50	6.53
Popularna kremska	25.54	2.34	2.25	4.10	2.55	12.84
Popularna paprykowa	22.59	3.72	2.32	2.32	2.44	4.76
Mean – Średnia	23.64	2.48	2.29	3.71	2.49	6.55
LSD – NIR $\alpha \leq 0.05$	1.98		0.19		n	

n – not significant at $\alpha \leq 0.05$, V – variability coefficient, %.
n – nieistotne przy poziomie $\alpha \leq 0{,}05$, V – współczynnik zmienności, %.

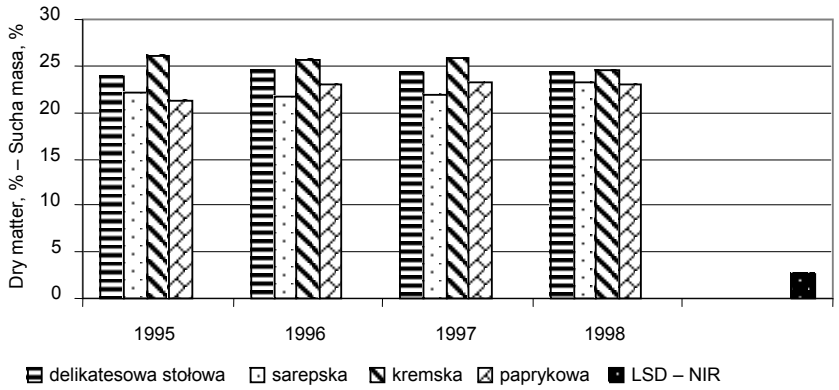

Fig. 2. Fluctuation of dry matter content in the mustard
Rys. 2. Fluktuacja zawartości suchej masy w musztardach

Table 2. Influence of the weather on mustard quality (mean for four varieties)
Tabela 2. Wpływ warunków meteorologicznych na jakość musztard (średnia czterech gatunków)

Years Lata	Mustards feature – Cechy musztard		
	content of dry matter zawartość suchej masy %	acidity kwasowość %	content of NaCl zawartość NaCl %
1995	23.31	2.30	2.33
1996	23.70	2.32	2.65
1997	23.77	2.29	2.55
1998	23.79	2.25	2.42
LSD – NIR $\alpha \leq 0.05$	n	n	0.20

n – not significant at $\alpha \leq 0.05$.
n – nieistotne przy poziomie $\alpha \leq 0{,}05$.

and extremely wet (1997), significant differences between mustard types were recorded. No such differences were found in wet 1998. The highest difference of dry matter content occurred in extremely dry 1995 and it referred to kremska and paprika mustards (Fig. 2).

Acidity of tested mustards – recalculated onto acetic acid – regardless the studied factors, was 2.29%, on average (Table 1). That trait depended on mustard type. Dainty mustard was characterized by the highest, and sarepska – the lowest acidity. Sarepska, kremska and paprika mustards appeared to be homologues referring to that trait. Sarepska and paprika were the most stable, and dainty – the least stable mustard (Table 1). Weather conditions during mustard cultivation did not exert significant influence on the discussed trait (Table 2). However, tested product showed fluctuations due to varied atmospheric conditions during mustard vegetation. Dainty mustard was characterized by the highest acidity in the first three study years, then kremska in 1995, and sarepska a year later. Other mustard types did not significantly differ referring to the trait values. The tested mustards did not differ with the acidity levels in wet 1998, either (Fig. 3).

Table 3. Organoleptic valuation of mustard and variability coefficients
Tabela 3. Ocena organoleptyczna musztard oraz współczynniki ich zmienności

Kind of mustard Rodzaj musztard	Mustards feature – Cechy musztard							
	taste smak		flavour zapach		consistency konsystencja		colour and appearance barwa i wygląd	
	9° score	V	9° score	V	9° score	V	9° score	V
Delikatesowa − stołowa	8.75	5.17	8.75	5.17	8.75	5.17	8.00	9.23
Popularna sarepska	8.75	5.17	8.75	5.17	7.75	11.17	8.00	9.23
Popularna kremska	8.75	5.17	8.5	6.14	8.75	5.17	8.00	9.23
Popularna paprykowa	8.75	5.17	8.75	5.17	8.25	10.50	8.50	6.14
Mean – Średnia	8.75	5.17	8.69	5.41	8.38	8.00	8.13	8.46
LSD – NIR $\alpha \leq 0.05$	n		0.10		0.12		0.15	

n – not significant at $\alpha \leq 0.05$, V – variability of coefficient, %.
n – nieistotne przy poziomie $\alpha \leq 0{,}05$, V – współczynnik zmienności, %.

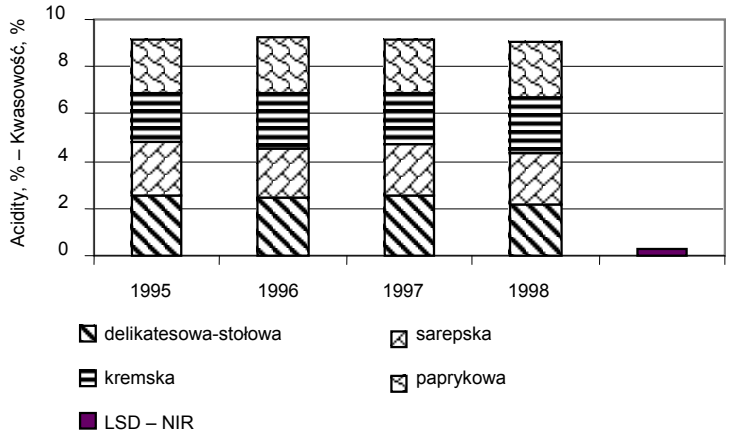

Fig. 3. Fluctuation of mustard acidity
Rys. 3. Fluktuacja kwasowości musztard

Sodium chloride content was 2.49%, on average (Table 1). The tested mustards did not significantly differ with the salt content; only tendency to its higher level was observed in kremska as compared to other mustards. Dainty mustard had the lowest variability coefficient for that trait, which proves its high stability; the highest value was recorded for kremska mustard (Table 1). Salt content varied in subsequent years. The highest NaCl content was observed in 1996, the lowest in 1995. The difference was

insignificant in 1995 vs. 1998 and 1996 vs. 1997 (Table 3). Own study indicates that significant differences of salt content in the tested products occurred only in 1995-1996 between dainty and kremska mustards (Fig. 4).

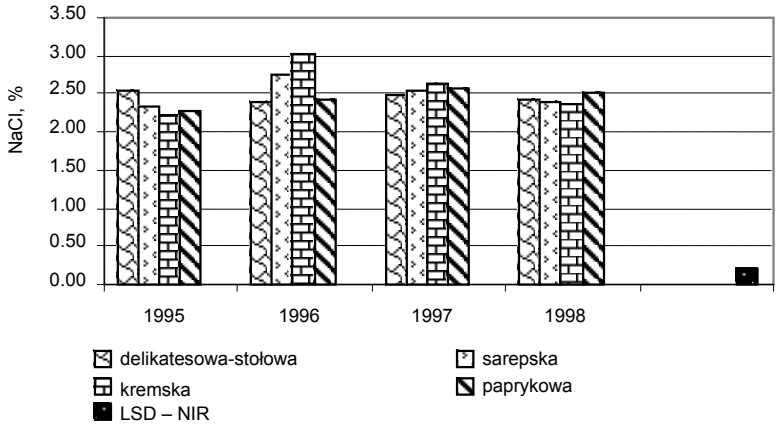

Fig. 4. Fluctuation of NaCl in the mustard
Rys. 4. Fluktuacja zawartości NaCl w musztardach

Among evaluated physicochemical traits of mustards, dry matter content appeared to be the most stable, NaCl content – the least. Referring to stability, tested mustards can be lined up in a following sequence: dainty > paprika > sarepska > kremska. Low coefficients of the tested traits prove high stability of corresponded mustards (Table 1).

Mean taste value of the assessed mustards was high amounting to 8.75 in 9° grade (Table 3). Mustard types did not differentiate that trait. Only in 1996, the taste was slightly worsened, which should be contributed to plant's water stress and worse mustard seed developing (Table 4). The tested mustard types did not differ with that trait value in the study years (Fig. 5).

Table 4. Influence of the weather on mustard organoleptic valuation (mean for four varieties)
Tabela 4. Wpływ warunków meteorologicznych na cechy organoleptyczne musztard (średnia czterech gatunków)

Years Lata	Mustards feature in 9° score – Cechy musztard w skali 9°			
	taste smak	flavour zapach	consistency konsystencja	colour and appearance barwa i wygląd
1995	9.00	8.75	8.75	8.50
1996	8.00	8.50	8.00	7.50
1997	9.00	8.75	8.25	7.75
1998	9.00	8.75	8.80	8.75
LSD – NIR $\alpha \leq 0.05$	0.20	0.15	0.40	0.42

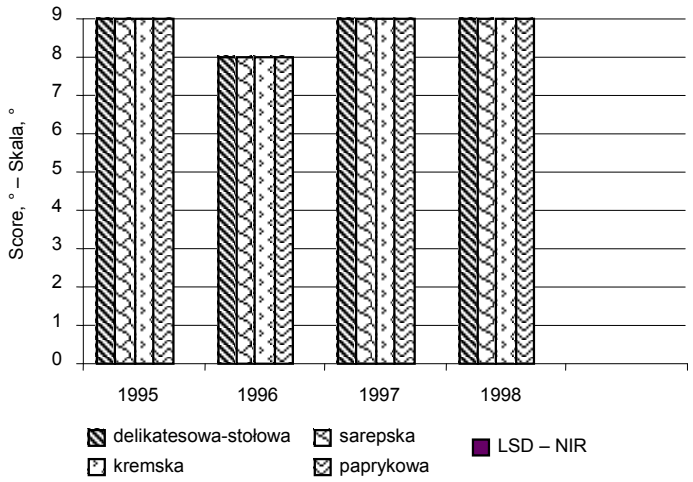

Fig. 5. Fluctuation of mustard taste
Rys. 5. Fluktuacja smaku musztard

Scent of the tested products gained high 8.69 score in 9° grade, on average (Table 3). Kremska mustard got the lowest score. Other types appeared to be homologues referring to that trait. The weather conditions modified the product's scent only to a low extent (Table 4). The lowest value of the trait was recorded in 1996, when extreme drought was during flowering and silique maturation periods. Mustard scent remained at a stable level in other study years. Interaction of weather conditions with mustard type appeared to be significant (Fig. 6). In 1995, the highest scent difference occurred between kremska and other mustards. In 1996, sarepska and kremska, in 1997 – paprika, and in 1998 – dainty mustard achieved the lowest scores.

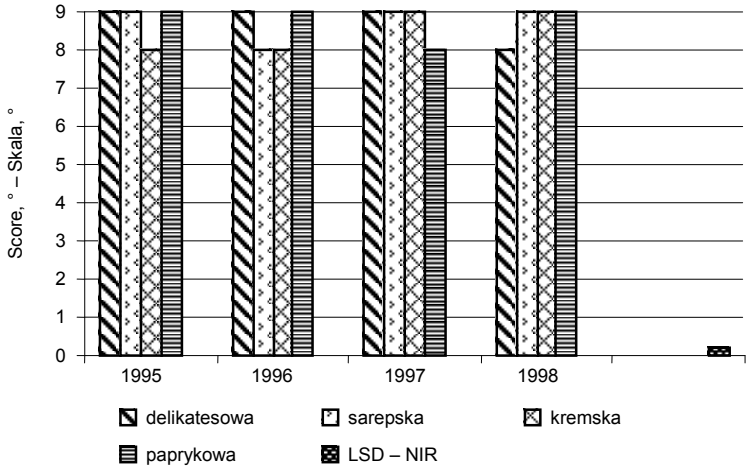

Fig. 6. Fluctuation of mustard flavour
Rys. 6. Fluktuacja zapachu musztard

The mean mustard consistence was scored for 8.38 in 9° grade (Table 3). The lowest value achieved sarepska, the highest – dainty and kremska mustards. The trait was the most stable in the case of both latter mustards. Influence of weather conditions during vegetation and storage on mustard consistence was significant (Table 4). Mustard gained lowest scores in 1996, highest – in 1998. Interaction of weather conditions and mustard types indicated that consistence of sarepska as compared to other mustards was worse. In 1996, paprika gained the lowest, sarepska – the highest scores for consistence (Fig. 7).

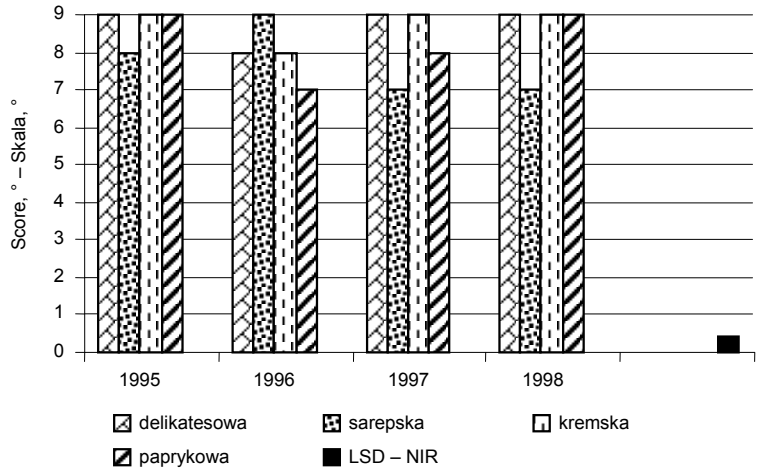

Fig. 7. Fluctuation of mustard consistency
Rys. 7. Fluktuacja konsystencji musztard

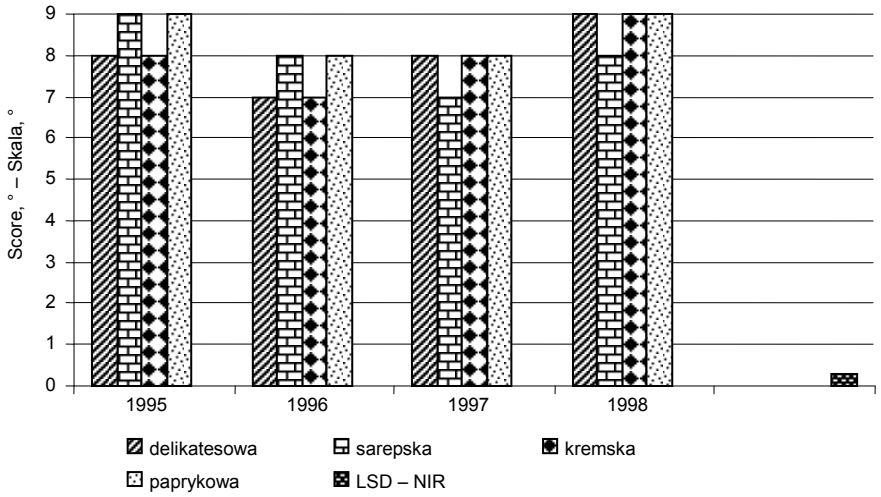

Fig. 8. Fluctuation of mustard colour and appearance
Rys. 8. Fluktuacja barwy i konsystencji musztard

Paprika mustard had the highest scores for colour and structure; that type was also characterized by the lowest variability coefficient (Table 3). The assessed trait varied in the subsequent study years (Table 4). Products in 1998 achieved the highest scores for colour and structure, in 1996 – the lowest. Interaction between study years and particular mustard types was also observed (Fig. 8). In following study years, difference between the highest and the lowest values remained at constant level. Sarepska and paprika mustards got higher scores for that trait in 1995-1996, and dainty along with two previously mentioned mustards were better in subsequent years.

DISCUSSION

The tested products were characterized by varied content of dry matter, acidity and sodium chloride content, which was mainly associated with varied recipes of particular mustard types [Instrukcja technologiczna... 1963, Zakładowe normy... 2002]. Recipe modifications are made to widen the assortment and adjust to consumer's demands. The taste assortment can be widened by introduction of such additives as beer, wine, whisky, honey, garlic, or onion, etc. [Hemingway 1995, Man and Weir 1988]. Differences of dry matter content may depend on white mustard seed content in the recipe. In the opinion of Cui et al. [1993], and Cui [1997], the species has more gelating substances that absorb water than sarepska mustard. Usually, in order to achieve expected consistence of mustard with large amounts of white mustard seeds, more water is added than in the case of mustards with sarepska mustard seed domination. Thus, different dry matter content may be recorded at the same consistence.

Most of analysed traits, important at mustard production, varied depending on interaction of various factors such as: gelating substances content in seeds, seed water absorption capacity, or mustard seed genotype. It was earlier confirmed in studies of Murawa et al. [2001, 2003], Raney and Rakow [1999], Agnihotri and Kaushik [2003], Brown et al. [1999], Katepa-Mupondowa et al. [1999], Piętka et al. [2004].

Many authors [Clercq 1999, Murawa et al. 2003, Cui et al. 1993] also indicate a great influence of raw material quality on final product. They found that even 1.5-fold quality differences referring to particular traits could occur. The total variability may result from variability of seeds in the same or different raw material lot, or/and variability of gelating substances content that determine their water absorption property. There may be much more reasons for that variability, because not every trait is controlled at each production stage, nor in semi-products and final products.

Results achieved by Wałkowski [1997], Piętka et al. [2004], Raney and Rakow [1999], Hemingway [1995], Man and Weir [1988] indicate significant influence of chemical composition of mustard seed composition that is a principle material for mustard production, on final product quality. Glucosinolans contents in mustard seeds determine mustard quality, because they influence on the spiciness of a final product. White mustard seeds contain sinalbin, and black mustard seeds – sinigrin. Both glucosinolans release volatile oils – making mustard hot and spicy taste – due to mirosinase enzyme at the presence of water [Hemingway 1995]. Under normal conditions, enzyme does not meet substrate and no toxic products are released. But when plant tissue is

injured or crushed, then glucosinolans make a contact with mirosinase and allyl isothiocyanate (at black and sarepska mustards), p-hydroxybenzyl isothiocyanate (at white mustard) or other derivative compounds are formed [Hemingway 1995].

Gelating substances in mustard seeds, mainly in seed cover of white mustard, have an important effect on final product's consistence and stable emulsion [Raney and Rakow 1999, Hemingway 1995]. Seed cover of sarepska mustard contains small, while that of white mustard – large amounts of the component [Woods and Downey 1980]. Cui et al. [1993] achieved stable oil-water emulsion (40% of oil in water) containing 1% of mustard gelating substances in the solution.

Production process beginning with the raw material supply through achievement of a final product is also very important. Raw material should be characterized by a proper colour of mature seeds, shine, natural scent, proper humidity and should be pure [Wałkowski 1997]. In a case of intended long-term storage of seeds, their humidity should not exceed 10.5%, which protects against unfavourable changes within the material. During seed processing (drying, de-oiling) as well as during mustard production, proper thermal conditions not exceeding 52°C [Hemingway 1995] or 70°C [Lloyd 1911, Instrukcja technologiczna... 1963] should be maintained. Temperature exceeding may result in mirosinase inactivation, which will make it impossible to produce volatile mustard oils and, in consequence, will worsen the taste and scent of final mustards. Thermal conditions during mustard production also affect the formation of a proper product's consistence. In opinion of Cui et al. [1993], Cui [1997] viscosity of 1% solution of mustard gelating substances increases 2-fold at 10°C in relation to 50°C. In order to achieve harmonized taste-scent flavour, wet-ground mash is subjected to de-aeration and seasoning for about week [Hemingway 1995, Instrukcja technologiczna... 1963]. Diversity of mustard tastes results from a consumer's regional habits. English mustard is produced from ground black and white mustard seeds with fruit acids addition. American mustard contains only white mustard seeds. All seeds are soaked to remove (extract) gelating substances in seed cover. Then, so-called *wet grinding* in colloid mill is performed, which results in a high viscosity increase. A final product is coloured with curcuma to get more apparent yellow colour. German mustard contains mainly white mustard seeds with small addition of sarepska mustard seeds to make taste spicier. Various versions contain different herbs, spices and vinegar, French mustard (Dijon) contains only brown seeds of sarepska mustard. They are washed and soaked, then ground with vinegar, grapefruit juice or wine, fruit acid, salt and spices addition. Grinding is performed at two stages. The first one is preliminary grinding aiming to crush the seed cover and its easy removal during wet sieving. Remaining kernels are blended to a paste form. Final semi-product is seasoned for about week in large reservoirs with periodical stirring to de-aerate.

Recently, both mustard recipes and technological process have been modified. Whole seeds, partially ground or in a form of paste have been applied. Taste assortment has been widened by introduction of additions such as beer, wine, whisky, garlic, onion, etc. [Hemingway 1995, Man and Weir 1988].

CONCLUSIONS

1. Tested types of mustards appeared to fulfill Polish Norm [PN-A-86964 2002].
2. Content of sodium chloride in mustards varied in the study years, which proves the great variability of the component in the product's recipe.
3. Referring to stability, tested mustard types can be arranged in the following sequence: dainty > paprika > sarepska > kremska.
4. Paprika and sarepska mustards were characterized by the highest changes of dry matter content and at the same time the lowest stability of the product's acidity.
5. Among the compared physicochemical traits, dry matter was the most stable, NaCl concentration – the least stable. Of organoleptic traits, mustard's taste was the most stable, its colour and structure – the least.
6. In total, dainty appeared to be the most stable, and sarepska – the least stable mustard referring to both physicochemical and organoleptic traits.

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OCENA BEZPIECZEŃSTWA ZDROWOTNEGO MUSZTARD W ASPEKCIE OBOWIĄZUJĄCYCH NORM

Streszczenie. Wyniki badań oparto na produkcie otrzymanym w Wytwórni Octu i Musztardy w Parczewie w latach 1995-1998. Podstawowym surowcem do produkcji musztard były dwie odmiany gorczyc: Nakielska (gorczyca biała) i Małopolska (gorczyca sarepska). Czynnikami doświadczenia były cztery rodzaje musztard (delikatesowa − stołowa, popularna sarepska, popularna kremska, popularna paprykowa). Do oznaczeń fizykochemicznych i organoleptycznych pobrano próbki musztard po 1-5 g. Badania wykonano w trzech powtórzeniach. W próbach oznaczano: suchą masę – metodą wagową, kwasowość – metodą miareczkową, zawartość NaCl – metodą Mohra, ocenę organoleptyczną przeprowadzono w 9-stopniowej skali (smak, zapach, konsystencja, barwa i wygląd). Statystyczne opracowanie wyników badań wykonano za pomocą analizy wariancji. Istotność źródeł zmienności sprawdzono testem Fishera-Snedecora. Istotność różnic oceniono testem Tukey'a. Badane parametry jakości czterech badanych musztard są zgodne z PN-A-86964 [2002]. Zawartość NaCl w musztardach okazała się zmienna w latach badań, co świadczy dużej labilności tego składnika w recepturze produktu. Pod względem stabilności analizowane rodzaje musztard można uszeregować następująco: delikatesowa stołowa > popularna paprykowa > popularna sarepska > popularna kremska. Największymi zmianami w zawartości suchej masy, a jednocześnie najmniejszą stabilnością kwasowości produktu charakteryzowały się musztardy: paprykowa i sarepska. Spośród porównywalnych cech fizyko-chemicznych musztardy najbardziej stabilna okazała się zawartość suchej masy, najmniej zaś – stężenie NaCl. Z cech organoleptycznych najbardziej stabilny okazał się smak musztard, natomiast najmniej barwa i wygląd. Najbardziej stabilną, pod względem badanych cech fizykochemicznych i organoleptycznych, okazała się musztarda delikatesowa, a najmniej musztarda sarepska.

Słowa kluczowe: musztardy, rodzaje musztard, jakość

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