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QUALITY OF FRENCH-FRIES OF 37 POTATO CULTIVARS IN CONDITIONS OF APPLICATION OF GROWTH REGULATORS MIVAL AND POTEITIN

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ABSTRACT

Use of growth regulators at potato cultivation and its effect on subsequent french-fries quality. The qualitative analyses of french-fries were based on tuber samples from a field experiment carried out on sandy-loamy soil in 1990-1992 in Parczew, Biała Podlaska Province. The experiment was set up with randomized subblocks in three replications. The subblocks of 1st row were made by the growth regulators: a) Mival concentration 500 mg × l^{-1} water; b) Poteitin concentration 10 mg × l^{-1} water; c) the control with distilled water. The growth regulators were applied onto the tubers in a spray form just before the planting. A factor of 2nd row was made by 37 potato cultivars out of all the earliness groups. Regulator Mival contributed to french-fries taste and flavour improvement in the years of a warm and dry potato vegetative period and Poteitin preparation has contributed significantly to improve french-fries consistency. Both growth regulators concurred to increase of fat absorptiveness of french-fries.

Key words: french-fries, potato, quality, growth regulators

INTRODUCTION

Tubers for fried food products should meet the highest quality requirements. These products are obtained through frying raw potato tubers whole, or more often, adequately cut in fat.

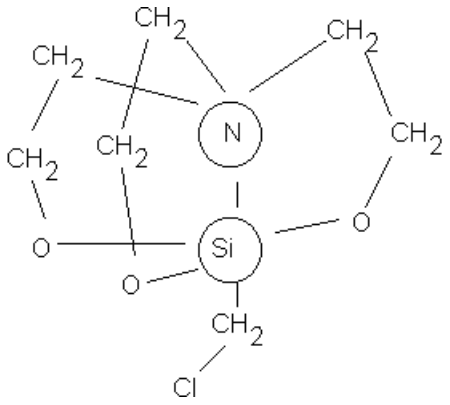
Alike Poland, in the western countries chips and french-fries are most popular. Their production is quite simple, yet it presents numerous technological difficulties [9, 10, 14, 15, 24, 16, 21]. French-fries as a ready product should be of high quality, i.e. show a light golden yellow colour, its outer part being crispy, delicate without any hard, gummy or leathery consistency. The inside is not expected to be mealy or separate from crust, while moisture being conditioned by a french-fries type should reach – 50-70% [2, 10, 16, 24]. The most important parameters of raw material for french-fries production go as following: tubers of oblong or elongated-oval shape, transversal >45 mm, smooth skin, no cracks, mechanical damages or shallow buds, insusceptible to dark spotting, without necrosis or hyperchromatism, no rust-coloured or green spotting; consumer type B-BC (Consumption type B – tubers of middle dense but not crumbling after boiling parenchyma, comprehensively useful, that type cultivars are mostly processed for chips, instant soups and wet products (canned food); consumption type BC comprehensively useful, less flour-like, slightly loose): raw tuber flesh darkening should amount to > 6.5, cooked > 7.5 in the 9-score scale; proper chemical composition: starch content 14-18%; reducing sugars content up to 0.5%; sugar sum content up to 1% [2, 3, 16, 24, 27].

Out of the agroecological factors affecting quality of potatoes as a raw material for french-fries production in a significant way the following ones ought to be mentioned: cultivar properties, mineral fertilization, herbicide use, time and storage conditions etc. Nitrogen fertilization applied in high doses deteriorates french-fries quality causing their colour darkening and increase of fat absorption [5, 20]. According to Leszczyński and Lisińska [5] early potato planting can partly absorb the negative effect of intensive nitrogen fertilization on potato tuber quality. A french-fries colour is also affected by the temperature and tuber storage time [3, 27]. It is connected with reducing sugars content increase in tubers as early as after 2 month-storage period [27]. Leszczyński and Lisińska [4] assume that potato tuber chemical composition may change due to herbicides use at cultivation. On the one hand, they increase average tuber weight, while on the other hand, induce a decrease of dry mass and starch content, while amount of sugars sum and reducing sugars as well as amide nitrogen go up. A similar effect is observed at delayed planting. Fried products obtained out of such material absorb more fat and show a darker colour [10. The synthetic growth regulators operating as stimulators or inhibitors in dependence on the conditions or character of a process they participate in may have too tan influence on fried products quality [28, 1, 18, 6]. In the literature there are not much data available considering this subject. According to Sawicka [19] Mival and Poteitin application caused the decrease of content of fat in the chips, with somebody's the higher positive effect of examined regulators was observed in the group of late cultivars while the lower was in the group of middle late cultivars. Mikos-Bielak et al. [12] found that due to synthetic growth regulator Poteitin, the decrease of oligo- and polysaccharides occurred. Therefore, the present work aims at determination the effect of synthetic growth regulators Mival and Poteitin on the quality of french-fries obtained from 37 potato cultivars. Studies were carried out several years ago but the results are still significant because over 80% potato cultivars used in tests is cultivated. Moreover, studies using such large set of cultivars make possible to eliminate great phenotypical variability of the species, that will increase their usability in practice.

MATERIALS AND METHODS

The present work is based on a field experiment carried out on sandy loamy soil in Parczew in the years 1990-1992. Experiment was set by means of randomized sub-blocks in dependent system, in three replications. The first order factors were cultivation technologies: a) with Mival at 500 $mg \cdot dm^{-3}$ conc.; b) with Poteitin at 10 mg × dm^{-3} conc.; c) control object with distilled water. The second order factors were 37 potato varieties of all earliness groups including 34 Polish and 3 Dutch varieties (Diamant, Escort, Premieur). Water solutions of both growth regulators were applied for spraying the potatoes before setting. Their concentrations were applied according to producer recommendations.

Mival and Poteitin are commercial names for the preparations. Irkuckij Institut Organiczeskoj Chimii (Russia) is a producer of Mival, and Institut Bioorganicznoj Chimii na Naftochimii NAN (Ukraine) is a producer of Poteitin. Their concentrations were applied according to producer recommendations. Both preparations used are the synthetic growth regulators in form of water-soluble fine-crystalline powder that is slightly toxic, non-allergic or carcinogenic. An active substance of Mival is 1-(chloromethyl) silatrame (1-CMS). It is organic silicon-derivative compound (siloxan derivative) of the following formula:

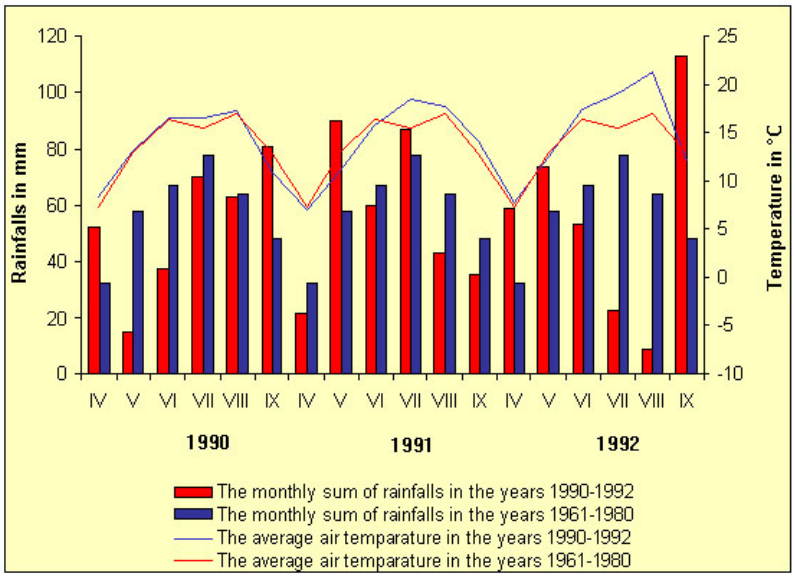


The compound decomposes into SO_2, CO_2, H_2O, monoethyloamine, urea or other small MW compounds being the components of the preparation [22, 1]. It does not invoke allergies, it is little toxic, lethal dose for the preparation is 3090 mg/kg body weight. Mival stimulates protein and nucleic acid biosynthesis [23, 1]. Poteitin is pyridine derivative of cyclic structure. succinic acid and 2,6-dimethylpyridine N-oxide salt is the active substance of the preparation [1, 18]. Poteitin regulates oligo-and polysaccharide biosynthesis [12]. The organic and mineral fertilization was maintained at the constant level (100 kg N, 100 kg P_2O_5, 150 $K_2O \times ha^{-1}$ and 250 dt $\times ha^{-1}$ manure). Seed material was made by elite seed. From the field experiment there were collected 20 potato tubers out of 10% of each 80 potato busk-plot for futher examination. The potato tubers were of > 55 mm diameter, with no green spots or damage. The tubers for french-fries evaluation were peeled first, then cut with a slicing machine. The french-fries were of the following dimensions: 5 × 5 mm section and > 5 cm length. After cold water rinsing, they were dried superficially, centrifuged and fried in vegetable oil, in a single phase. Out of every field experiment replications there were 10 portions of french-fries fried, being considered as technological replications. Charge of one frying cycle amounted 200 g of raw french-fries per 3 l of oil. The french-fries were fried in vegetable oil at temperature 180°C, each portion for 8 min on average. The oil was changed after 10 portions of the french-fries have been fried. Evaluation involved colour, consistency, taste and flavour as well as fat content in french-fries. Colour estimation was performed according to the following scores: 5 – light golden colour, very uniform; 4 – light golden colour, ununiform; 3 – light golden to dark golden colour with brown edging, rather ununiform; 2 – slightly dark colour with brown spots, ununiform; 1 – dark colour with brown spots, very ununiform. Consistency estimation of french-fries was made after a 5-score scale where 5 – stands for very crispy surface, delicate tender pulp, 4 - crispy surface, tender pulp, a little loose; 3 – surface crispy enough, slightly granular or a bit sticky pulp; 2 – a little crispy surface, granular or sticky pulp; 1 – improper surface, improper sticky pulp. Taste and flavour were estimated according to a 5-score scale where 5 – stands for intensive taste and flavour, very good typical with a delicate fat after-taste; 4 – less intensive, good with a fat after-taste; 3 – fairly typical, a slightly perceptible strange after-taste and vapid flavour; 2 – a little typical, clearly perceptible strange after-taste and vapid flavour; 1 – atypical strange taste and flavour of rancid fat. French-fries quality was performed by a standing group of five people previously examined for sensoric predispositions, according to the PN-A-82201. Fat content determination in french-fries was performed after soxlet method.

The results were worked out statistically according to variance analysis method, the significance of differences was checked by Tukey`test.

The weather during the experiment was variable as shown in Figure 1.

Fig. 1. Rainfalls and air temperature during potato vegetation period in the years 1990-1992, according to IMGW at Włodawa



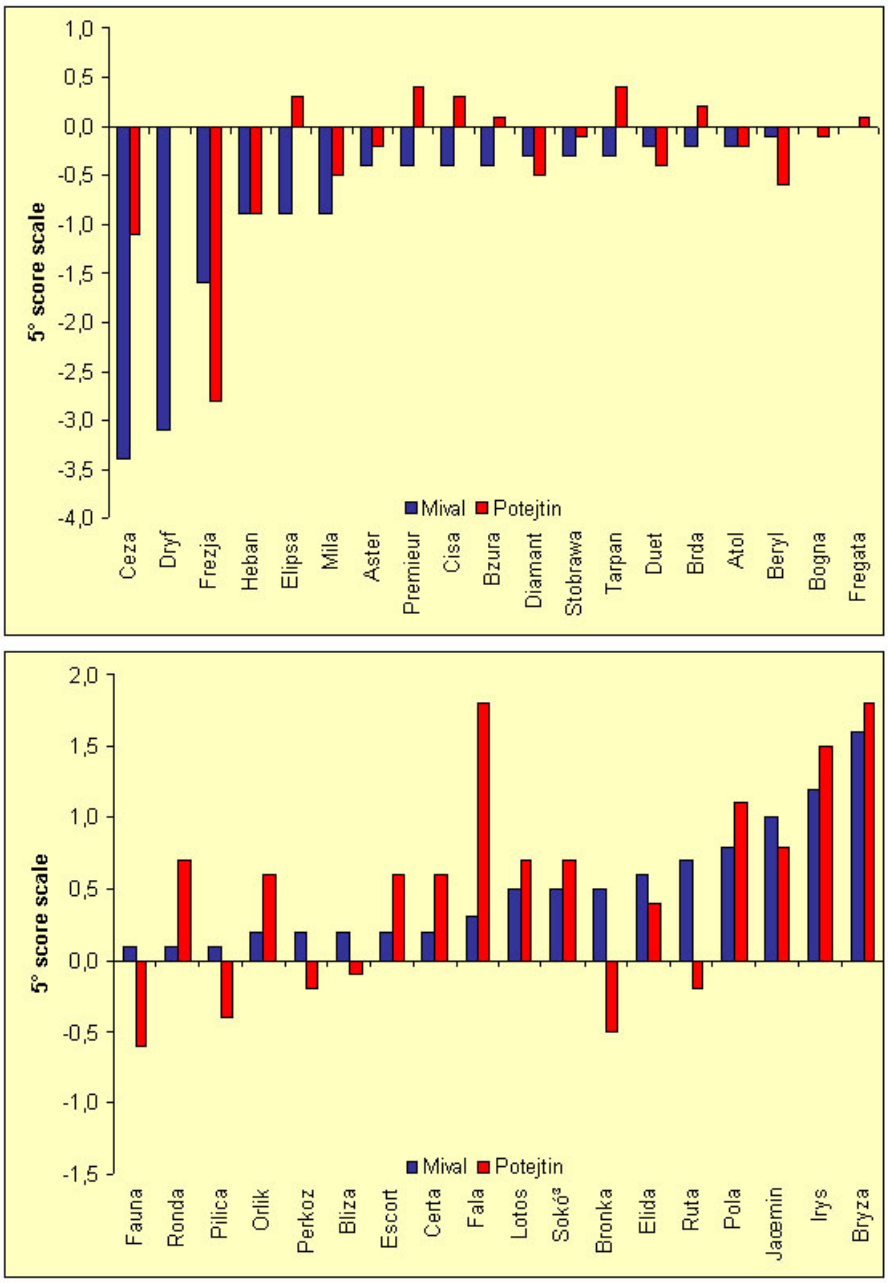
French-fries colour. None of the growth regulators studied modified french-fries colour significantly, as against the control. A product got better colour in the objects with Poteitin preparation use than in a object with Mival one (Table 1).

Table 1. The influence of years and growth regulators on some the traits development of french-fries (Mean for 37 potato cultivars)

Growth regulators	Years			Mean
	1990	1991	1992	
The colour in the 5-score scale				
Mival	4.2	4.2	4.2	4.2
Poteitin	4.4	4.4	4.4	4.4
Control object	4.3	4.4	4.3	4.3
LSD (α≤0,05)	n*			0.2
Mean	4.3	4.3	4.3	
LSD (α≤0,05)	n			
The taste in the 5-score scale				
Mival	3.6	3.9	3.7	3.7
Poteitin	3.6	3.5	3.5	3.5
Control object	3.5	3.6	3.4	3.5
LSD (α≤0,05)	0.2			0.1
Mean	3.6	3.6	3.6	
LSD (α≤0,05)	n			
The consistency in the 5-score scale				
Mival	3.4	3.4	3.1	3.3
Poteitin	3.7	3.8	3.4	3.6
Control object	3.5	3.5	3.4	3.4
LSD (α≤0,05)	0.3			0.2
Mean	3.5	3.5	3.3	
LSD (α≤0,05)	0.2			
The fat content in %				
Mival	19.75	19.73	19.55	19.68
Poteitin	19.37	19.02	19.13	19.17
Control object	18.89	18.85	18.93	18.89
LSD (α≤0,05)	n			0.17
Mean	19.34	19.20	19.20	
LSD (α≤0,05)	n			

The growth regulators used had a differentiated impact on the cultivars studied (Fig. 2). Significant deterioration in french-fries colour after a synthetic growth regulator Mival application was recorded in 4 cultivars (Ceza, Dryf, Frezja, Heban), while their colour improvement in only one cultivar (Bryza). However, Poteitin caused some favourable changes in french-fries colour in 3 cvs (Bryza, Irys, Fala) and significantly unfavourable in only 1 cultivar (Frezja).

Fig. 2. The differences in the colour of french-fries heated with Mival, Poteitin against control object in the differential, 5-score scale



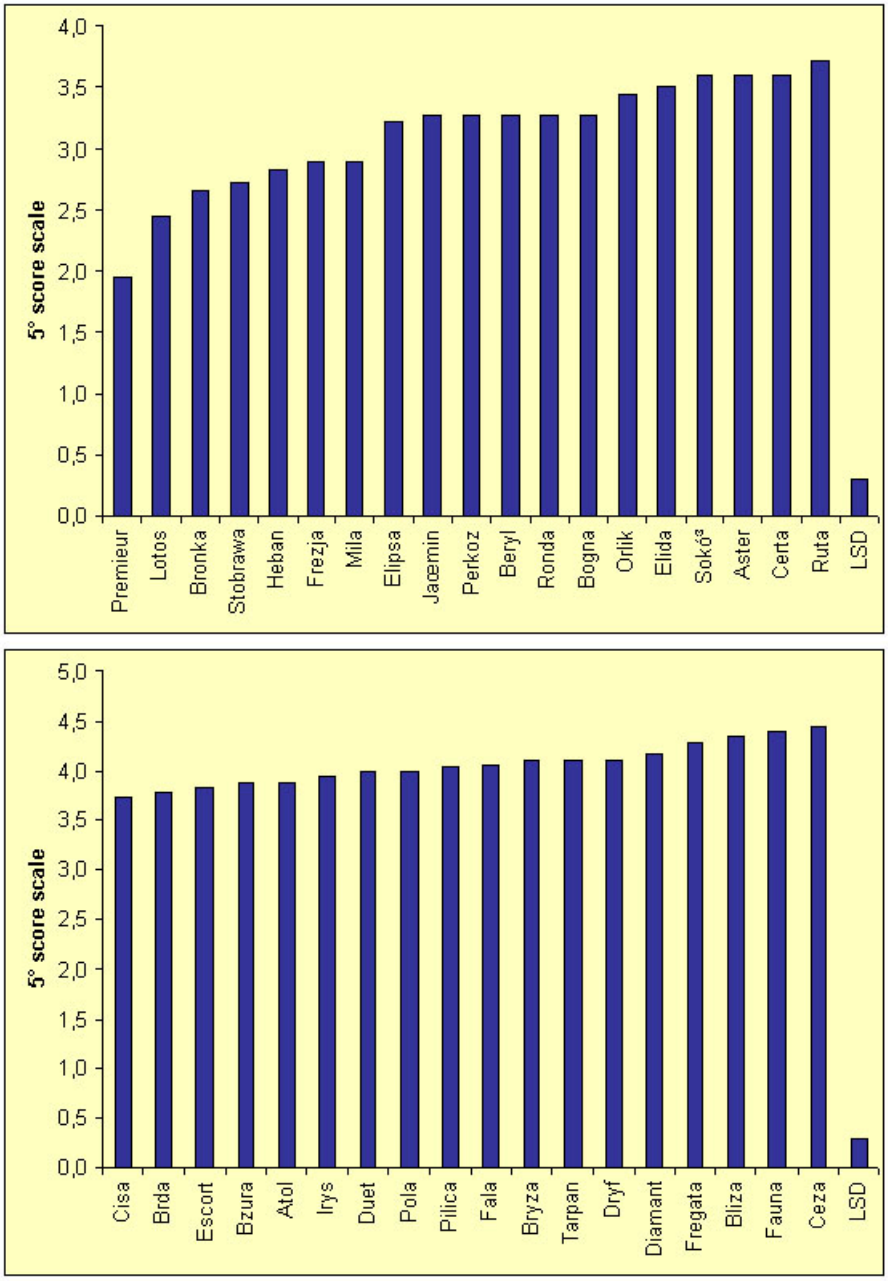
This property turned out to be connected with cultivar properties most (Fig. 3). A cultivar group where the tubers gave subsequent french-fries of the best colour (evaluation values 4.5 and > 4.5 in the 5 scale) included: Aster, Orlik, Elipsa, Jaśmin, Perkoz, Bliza, Elida, Fauna, Atol, Bogna, Brda, Certa, Cisa, Fregata, Diamant, Bzura, Stobrawa, Tarpan. The french-fries of the poorest colour (< 3.5 in the 5 scale) were: Frezja, Ceza, Fala.

Fig. 3. The influence of cultivars on the colour of french-fries (Mean for the years 1990-1992)

The meteorologic conditions over the experimental years have not differentiated this feature in a significant way (Fig. 1, Table 1).

French-fries taste and flavour were modified by the growth regulators. Mival preparation improved these features of product quality compared to control as well as to the object with Poteitin use (Table 1). This beneficial influence of Mival preparation on french-fries taste and flavour was observed in the years 1991-1992 at potato vegetation period when high mean air temperature and precipitation deficit were recorded.
Genetic traits of the cultivars examined differentiated the taste and flavour of a product (Fig. 4). In a group of cultivars which tubers allowed to obtain the french-fries of the best taste and flavour (values obtained 4.0 and > 4.0 at 5-score scale) included: Ceza, Fauna, Fregata, Bliza, Bryza, Diamant, Dryf, Fala, Tarpan, Duet, Pilica, Pola. The poorest taste and flavour of french-fries (< 3.0 at 5-score scale) was demonstrated by the following cultivars: Premieur, Lotos, Bronka, Stobrawa, Heban, Frezja, Mila.

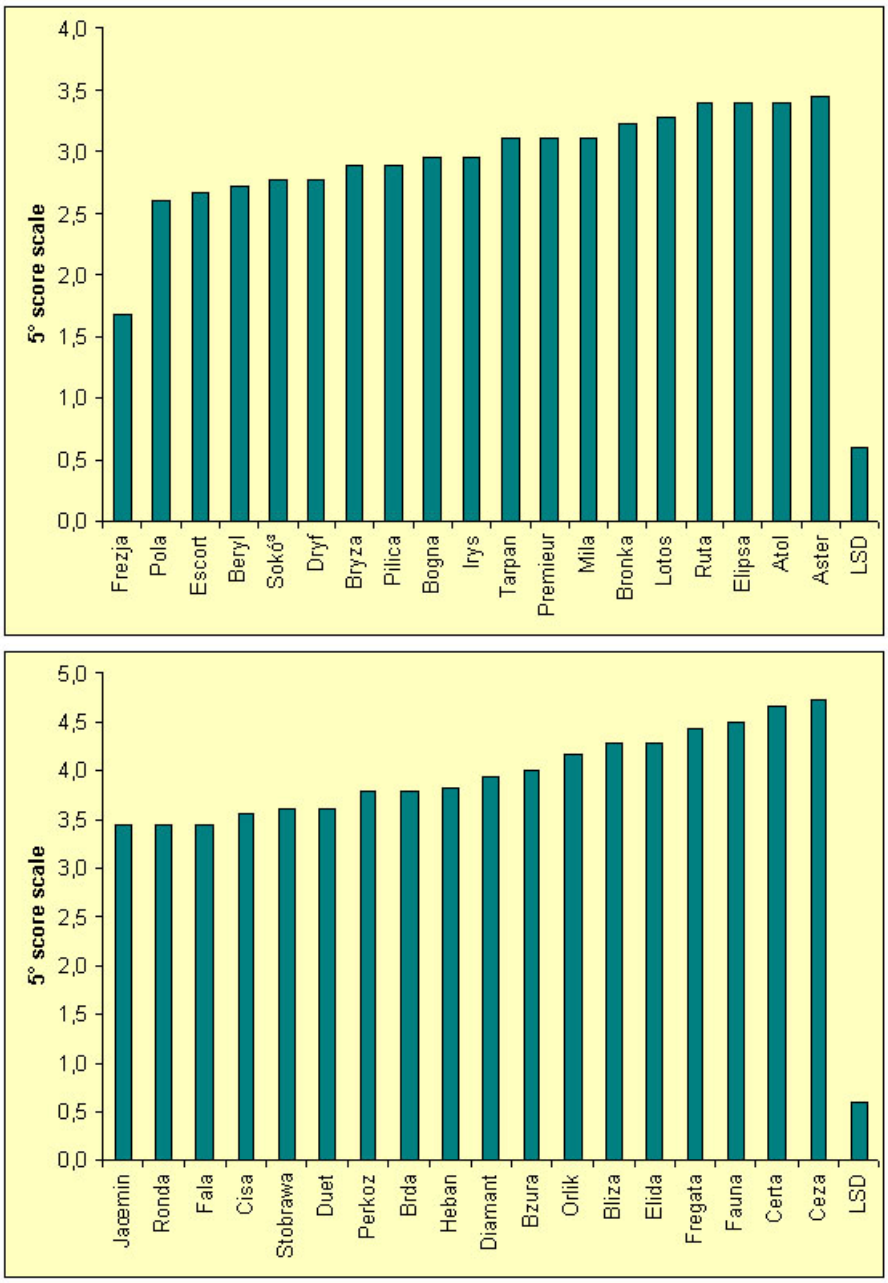
Fig. 4. The influence of cultivars on the taste and flavour in the 5-score scale (Mean for the years 1990-92)



French-fries consistency, just like their colour, depended on the growth regulators used and cultivar characteristics. Poteitin preparation has contributed significantly to improve french-fries consistency (Table 1). This product consistency in the samples with Mival preparation has not differed significantly from control.

The cultivar properties turned to be a factor of the greatest influence on fried tuber quality (Fig 5). The group of cultivars whose tubers provided subsequent fries of the best consistency (4 and > 4 in the 5 scale) contained: Certa, Ceza, Fauna, Fregata, Bliza, Orlik, Bzura. Poor consistency (< 3 in the 5 scale) showed the french-fries from the following cvs: Frezja, Irys, Beryl, Pola, Escort, Bogna, Bryza, Sokół, Dryf, Pilica.

Fig. 5. The influence of cultivars on the consistency in the 5-score scale (Mean for the years 1990-92)

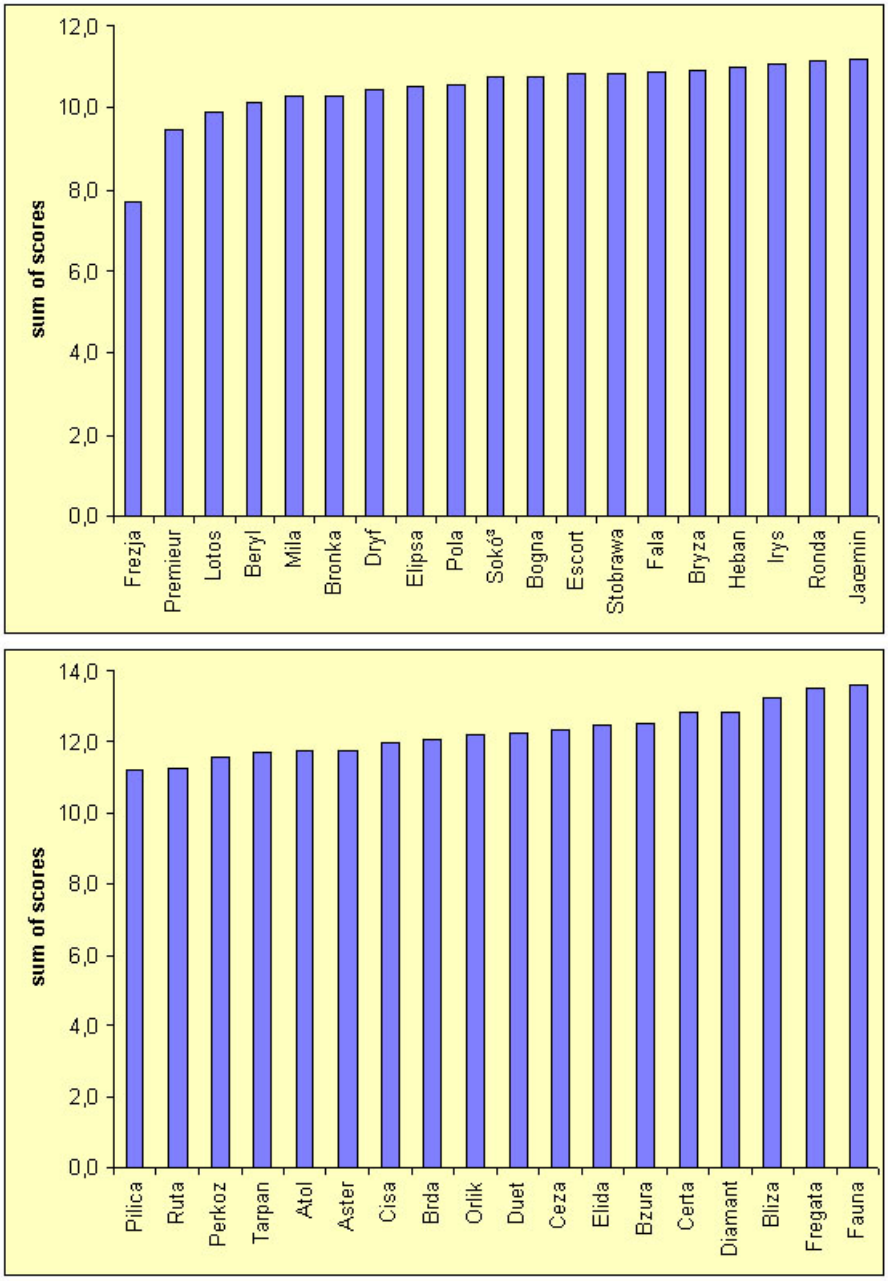


The weather conditions over the experimental period caused differentiation of french-fries consistency (Fig. 1, Table 1). A higher evaluation of the product, for this feature, was obtained in the years 1990-1991, the time of sufficient precipitation for potato at vegetative period than in the year 1992 with serious rain deficiency.

Taking into account the sensoric properties of french-fries, especially their colour, taste and flavour as well as consistency, the cultivars examined were divided into 3 groups:

- group of cultivars of the highest suitability for french-fries; sum of sensoric estimation points over 12: Brda, Orlik, Duet, Ceza, Elida, Bzura, Certa, Diamant, Bliza, Fregata, Fauna;
- group of cultivars of average suitability for french-fries; sum of points 11 to 12: Brda, Heban, Irys, Ronda, Jaśmin, Pilica, Ruta, Perkoz, Tarpan, Atol, Aster, Cisa;
- group of cultivars unsuitable for processing for french-fries sum of points below 11: Frezja, Premieur, Lotos, Beryl, Mila, Bronka, Dryf, Elipsa, Pola, Sokół, Bogna, Escort, Stobrawa, Fala (Fig. 6).

Fig. 6. Sequence of potato cultivars according to sum of scores of various sensory attributes (colour, taste and consistency) in french-fries

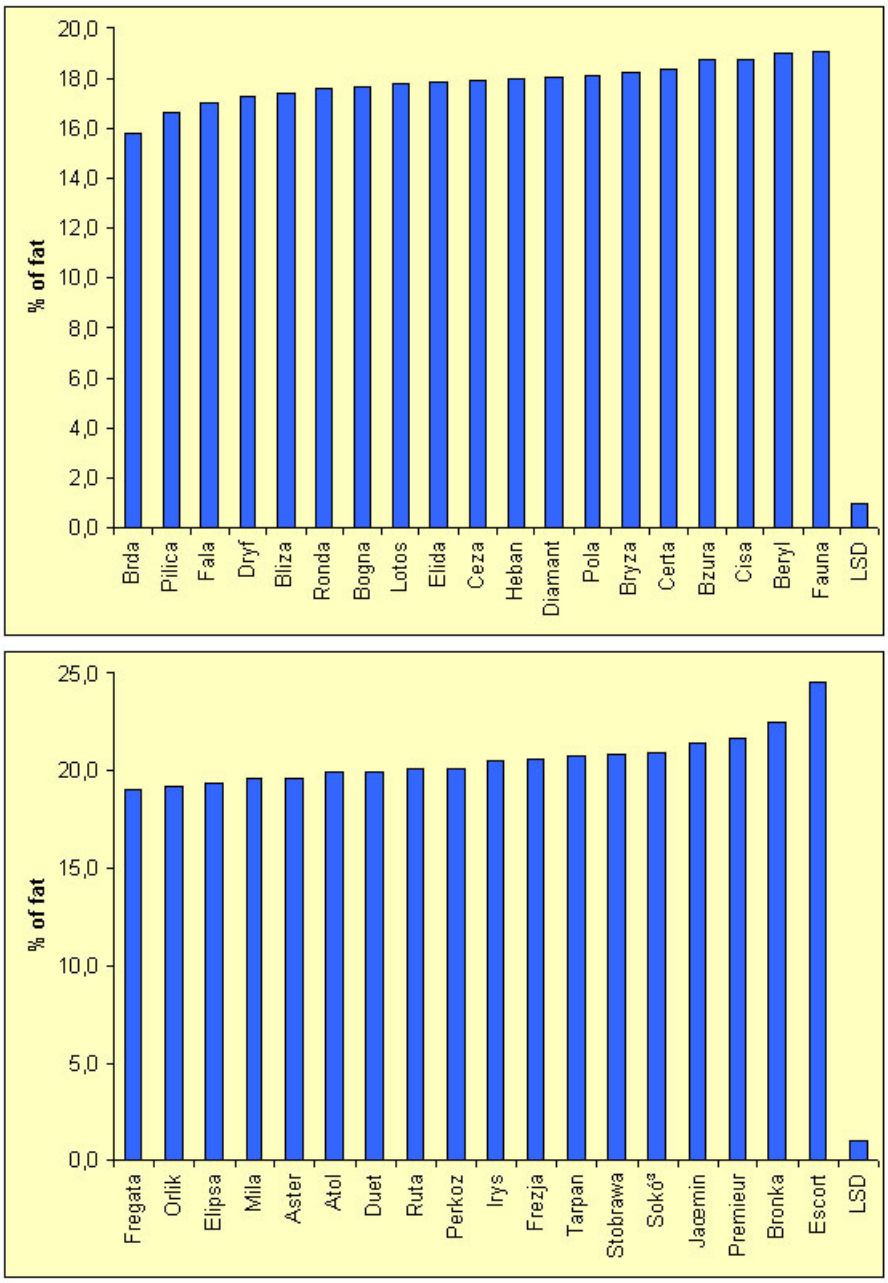


Fats content is one of the most substantial qualitative analyses at french-fries production. Their high content causes rise in production costs and lowers product value. Fat content in the french-fries examined turned to be a lot over the product standard. That could result from higher dry mass and starch content in the tubers of cultivars examined, technological reasons also could have occurred.

Application of new cultivation technologies with growth regulators has modified this property of french-fries significantly (Table 1) Both growth regulators concurred to increase of fat absorptiveness of french-fries, still only in Mival case it was significant.

Genetic traits of the cultivars under investigation determined fat content in french-fries extremely (Fig. 7). A variety of the least fat absorptiveness at frying process showed medium-late variety Brda (15.82 %), while the most - medium early Dutch variety Escort (24.53 %). A group of < 20% fat content in french-fries included 26 cultivars (Aster, Orlik, Duet, Jaśmin, Lotos, Beryl, Bliza, Elida, Fauna, Pola, Mila, Ronda, Atol, Bogna, Brda, Bryza, Certa, Cisa, Fala, Fregata, Diamant, Bzura, Ceza, Dryf, Heban, Pilica).

Fig. 7. The influence of the potato cultivars on the fats content in french-fries (Mean for the years 1990-1992)



The cultivars studied showed various responses to synthetic growth regulators (Fig. 8). Mival application brought about a significant decrease in french-fries fat content in 5 cultivars (Pola, Jaśmin, Diamant and Bronka), while in 14 cultivars (Frezja, Irys, Elipsa, Ruta, Orlik, Elida, Kos, Escort, Brda, Certa, Cisa, Fregata, Bzura, Dryf, Heban) a significant growth of their concentration in the product as against the control. Poteitin use as a growth regulator at potato cultivation incited significant decrease of fat content in the french-fries from tubers of 11 cultivars (Jaśmin, Perkoz, Beryl, Fauna, Mila, Bogna, Fala, Bronka, Pilica, Stobrawa, Tarpan), whereas in the french-fries from tubers of 12 cultivars – fat absorptivness rise (Aster, Frezja, Orlik, Bliza, Bryza, Certa, Fregata, Cisa, Ceza, Dryf, Duet, Heban) in relation to the control. A negative reaction to both growth regulators expressed by a fat absorptivness growth in french-fries occurred in 7 cultivars (Certa, Cisa, Dryf, Fregata, Frezja, Heban, Orlik).

Fig. 8. The differences in the fats content in the french-fries between Mival, Potejtin & control object in the differential scale

DISCUSSION

The synthetic growth regulators have modified the value of fried products from potato tubers. Mival preparation improved french-fries taste and flavour, while Poteitin contributed to their better consistency. However, both growth regulators increased fat content at the same time. In the literature there are no data available considering this subject. Still, it is probable that improvement of taste, colour or consistency of a fried product, that is french-fries, may result from some chemical composition changes in tubers treated with the growth regulators – Mival and Poteitin. The studies of Mikos-Bielak et al. [13] showed growth of reducing sugars content due to Mival preparation use at most of the cultivars examined, whereas changes in saccharose and starch content were differentiated. As to Poteitin preparation, the authors [12] proved that in most cultivars increase of reducing sugars content went together with a slight decrease of starch concentration and a drastic decline of saccharose content. That can testify inhibition of olio- and polysaccharides synthesis.

Growth regulators application at potato cultivation is comparable to herbicide introduction at potato cultivation as they can operate as inhibitors or stimulators for plants, subject to a dose and term of their use. Effect of

herbicide use on chemical composition of potato tubers was analysed by Leszczyński and Lisińska [4]. They claim that chemical preparations decrease dry matter content and in turn, starch content; besides, can incite an increase of nitrates and reducing sugars in tubers. The mentioned authors imply that french-fries taste and flavour is a resultant of aroma coming from the following materials: potato, oil, taste and flavour substance as well as technological processing. The authors maintain that potato grown with chemical means eg. insecticides, herbicides or potato cultivated at improper soil conditions may have unpleasant smell or taste that is transported to ready product. Summing up, a positive influence of both preparation on french-fries sensorial quality can be stated. However, as Mival and Poteitin conduce to a significant increase of tuber yield [19] the authors hold that some technological measures should be taken to regular process of french-fries production in order to improve product savouriness (for example, protection against surface darkening of the product and partial sugar washing out due to blanching; additional effect can be obtained by introduction the sulfites or complex-forming compounds). The present technological changes consider mainly the ways to decrease unfavourable reducing sugars content.

French-fries quality was significantly affected by cultivar properties. According to Frydecka-Mazurczyk [2] and Zgórska [24, 27] they are the reason for modification of potato tuber chemical composition, among others dry matter, starch and reducing sugars that influence fried products quality. A high content of reducing sugars, as it is believed by Lewosz [7], Lisińska [8], Zgórska and Frydecka-Mazurczyk [29], gives rise to decrease of taste qualities and fried product colour (bitter or sweet taste, brown colour). Improper french-fries colour is a result of reducing sugars condensation with the compounds containing free amino groups (Maillard reaction) and sugar caramelization [10]. In Lewosz`s opinion [7] a great quantity of free amino acids and saccharose contribute to chips and french-fries darkening. Lisińska [8] proved that the best indicator of potato tubers usability for french-fries production, apart from glucose and fructose content), is a content of saccharose and organic acids: oxalic, citric and apple one. A high saccharose content with tuber pH decrease conduce to fried products browning.
The studied cultivars response to Mival and Poteitin use expressed by a colour, consistency and fat absorptivness of french-fries turned out to be differentiated. Various reactions of potato cultivars to the preparations could be caused by the fact that these compounds can be inhibitors or stimulators of process of photosynthesis, tuberization process as well as defensive reactions of plant to pathogenic factors [28].

The weather conditions over the vegetative period influenced french-fries consistency significantly. Better consistency of a product was obtained in the years of sufficient precipitation amount at the vegetative time as against the year of its severe deficiency. Furthermore, Zgórska and Frydecka-Mazurczyk [26] stated that the years of little precipitation and strong insolation brought about lower content of reducing sugars, thus less darkening of fried products.

CONCLUSIONS

1. Growth regulator Mival contributed to french-fries taste and flavour improvement in the years of a warm and dry potato vegetative period and Poteitin preparation has contributed significantly to improve french-fries consistency.
2. Application of new cultivation technologies with growth regulators has modified of fat contents of french-fries significantly. Both growth regulators concurred to increase of fat absorptiveness of french-fries.
3. The cultivars response to the growth regulators used at potato cultivation expressed by colour, consistency of tubers fried as well as their fat absorptivness turned out to be differentiated; some cultivars reacted positively, others negatively and some group of cultivars did not show any significant changes.
4. Genetic properties determined a colour, consistency and fat content of french-fries extremely. Favourable colour of french-fries was recorded for the following cultivars: Fregata, Ibis, Elida, Diamant, Bzura, Aster, Cisa, Bliza, Duet, Stobrawa, Orlik, Jagoda, Certa, Bogna, Tarpan, Jagna, Perkoz, Jaśmin, Brda, Atol, Ronda. A group of cultivars with subsequent french-fries of the best consistency included: Certa and Ceza, Ibis, Fregata, Bliza, Orlik, Jagna, Bzura. A group of cultivars of the best suitability for french-fries with the highest sum of sensoric estimation points included: Brda, Orlik, Duet, Ceza, Elida, Bzura, Certa, Diamant, Bliza, Fregata, Fauna.
5. The weather conditions over the experimental years influenced french-fries consistency. Better consistency of the product was obtained in the years of precipitation amount sufficient for potato vegetative period as compared to the year with serious deficit.

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