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Soft-flesh fruits of *Capsicum frutescens* L. as the raw material for processing

ABSTRACT. The research material was made up of two selected homozygotic lines of *Capsicum frutescens* L. (Cf SF 1 and Cf SF 2) obtained as a result of pedigree selection of soft-flesh materials of different levels of capsaicinoid content. The physiologically mature fruits of this type are characterised by soft flesh that can be easily separated mechanically from inedible parts. Thus, it is not necessary to use heat treatment. The evaluated lines were characterised by a similar level of crops, and were different with regard to the number of fruits per plant and the average weight of fruit. Also, significant statistical differences were found as to the thickness of fruit walls, that is, a characteristic that determines the biotechnological performance of fruits in soft-flesh forms. The technological weight of the fruit, being the weight of the pericarp without the pedicle and the calyx sepal, was 55 g and 128 g, respectively, for Cf SF 1 and Cf SF 2 lines. Similar differences referred to the biotechnological weight, that is, technological weight minus the weight of the placenta including the seeds and the skin. The average biotechnological performance, which is the share of the biotechnological weight in the average weight of the fruit, was 62%. It means that the genotypes tested may be the source of raw material for obtainment of 2 kg of the concentrated juice from fruits collected from 1 m^2 of the crops. Regarding the product as biologically active food, the production capacity of genotypes may be interesting from the practical point of view.

KEY WORDS: *Capsicum frutescens* L., soft-flesh pepper, technological characteristics

Species of *Capsicum* genus are characterised by an exceptional nutritive and biological value of the fruits. They are the source of many physiologically active substances positively affecting human body functions, that is, anticarcinogenic compounds binding free radicals acting as antioxidants. These comprise vita-

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mins, carotenoids and flavonoids. A particular group is formed by capsaicinoids, that is, analgesic and anti-inflammatory compounds occurring in the so-called hot forms of these plants [Wall, Bosland 1998].

So valuable fruits may constitute a very good raw material for the production of biologically active food and nutraceutics and the processing suitability of the same depends on the volume and quality of crops as well as technical possibilities of the culture. So far, Polish breeders have been interested in annual pepper (*C. annuum* L.) only. Our research has also focused on this plant since mid 1990s. Recently, we have extended it by other species of *Capsicum* genus. Particular attention was paid to soft-flesh forms such as *C. frutescens* L. The characteristic referred to herein is conditioned monogenically by dominant allele *S* [Lippert et al. 1965], so it is relatively easy to transfer through hybridisation.

The essence of the tested characteristic of fruits is the possibility of disposal of the raw material, whose part, suitable in terms of processing, may be separated from inedible parts through mechanical separation of the same. It is an easy process that is not excessively energy-consuming, and first of all, it allows us to eliminate heat treatment of the fruits. The latter is unusually significant with regard to low durability of some biologically active substances when exposed to high temperatures.

Our hitherto performed research on genetic improvement of soft-flesh forms has consisted, among others, in matching and selection of hybrid materials within *C. frutescens* L. It aimed at obtaining the lines acceptable from the agrotechnical point of view, covering the habit of plants and fruits as well as the volume of crops. This study sums up all this work, whereas the main focus was the processing suitability of fruits and an attempt at evaluation of production capacity of selected lines.

METHODS

The research material was constituted by selected homozygotic lines of *C. frutescens* L. produced as a result of pedigree selection of soft-flesh materials, identified by Cf SF 1 and Cf SF 2 symbols. There are sweet and semi-hot forms with medium content of capsaicinoids, characterised by intense dark red colour of fruits in the phase of physiological maturity. Parent forms were matched in 1996, and individual selection including evaluation of issues was to begin in the subsequent season of vegetation. As early as in 2001, some of the selected materials turned out to be highly homozygotic. Lack of segregation in the subsequent year enabled us to prepare a genetically stable material for research to be carried

out in 2003, when the processing suitability and production capacity were evaluated for crops cultivated under unheated film tents.

Every year, the plants were cultivated according to agrotechnical indications for annual pepper. The plants were not cut, and their natural growth and habit was preserved. Every year, all fruits were picked at a single time in the second 10 days' period of September, and the volume of mature crops was determined. Biometrical measurements were carried out according to recommendations included in Descriptors for Capsicum [1995]. The volume of mature crops also determined early cropping [Nowaczyk, Nowaczyk 2002].

In 2003, Cf SF 1 and Cf SF 2 lines were represented by 40 plants each. Their technological weight was determined after the pericarp was separated from the pedicle and the fleshy calyx bottom. In soft-flesh forms it is a very simple operation that does not require the use of strength. In production conditions it is possible to shake the fruits off the plant. *S* gene determining the soft-flesh feature is of pleiotropic nature, and the second characteristic it conditions is very easy separation of the pericarp from the pedicle. The raw material prepared as specified above was used at further stages of the technological process. Apart from washing of the fruits, its principal part is separation of soft flesh from inedible parts, that is, from the placenta, seeds and the skin. The semi-finished product obtained this way constitutes the biotechnological weight of the fruit. Identification was performed in three series of 10 fruits each.

Results obtained during the experiment were subject to statistical analysis. The value of the lowest significant difference was determined by means of Tukey's test with P = 95%. In the tables, statistically different data were identified by different letters.

RESULTS

The five years' long selection of soft-flesh *C. frutescens* L. forms at our disposal resulted in obtaining a few lines that were potentially suitable for production. Two of these lines, subject to detailed research in 2003, were different with regard to the usable qualities analysed. Their crops, despite the differences observed, were uniform in terms of statistics (Tab. 1). Significant differences referred to the number of fruits collected from the plants as well as the area measuring unit, that is m^2. Few studies of the species subject to research make it difficult to compare and verify the results obtained, the more that we lack data concerning soft-flesh forms. An interesting quote here would be the results of research carried out in India on Sreelathokumary and Rajmony [2003]. Among 20 genotypes subject to their assessment a big differentiation of morphological and

cropping characteristics were found. The number of fruits oscillated between one hundred and more than two hundred, which provided maximum crops of 270 g per plant. The average weight per fruit was not more than 2 g. Small size of the fruits are typical of wild forms of *C. frutescens* L., cultivated in Central and South America [Depestre 1999; Castelano 2001]. In the above-presented background, the materials we were able to obtain seem to present a good level of biological advancement with regard to cropping and fruit size. The volume of crops was determined by the size and average weight of fruits. Cf SF 1 line was characterised by a higher level of the above-discussed characteristics, whereas no statistically significant differences were found with reference to the width of fruits. Referring to the above-mentioned research concerning the Hindu forms of the species, it must be mentioned that the average weight of fruits, length and width of the same was a few times higher in lines of our selection.

Table 1. The yield of mature fruit

Genotype	Yield in kg per		Fruit number per	
	plant	m^2	plant	m^2
Cf SF 1	0.84 a	3.76 a	13.7 a	61.6 a
Cf SF 2	0.68 a	3.06 a	21.9 b	98.6 b

Nearly all publications discussing quality characteristics of species belonging to *Capsicum* type, take into account the thickness of fruit walls. The varieties subject to research were different in this respect (Tab. 2). More valuable are genotypes with thicker walls, since these directly affect the weight of the fruit, and thus – the crop yield. In soft-flesh forms, they determine the biotechnological performance of fruits. Along with the increase in thickness of walls, the share of inedible parts, that is the placenta with seeds and the skin, is relatively decreased.

Table 2. Morphological characteristics of fruit

Genotype	Mean weight g	Length mm	Width mm	Wall thickness mm
Cf SF 1	61 a	112 a	57 a	4.83 a
Cf SF 2	31 b	89 b	45 a	3.48 b

The observation presented above refers to the significant part of the presented study, that is, the evaluation of suitability of the lines obtained in the process of production of puree that may be consumed directly as a food product or may be

diluted with water to obtain juice. The raw materials to be processed were fruits separated from the pedicle and the fleshy calyx bottom and calyx sepals. As it was noted in the method of research, the pedicle is easily removable with regard to natural separation of the pericarp tissues and the placenta from the pedicle, progressing along with ripening of the fruits.

Table 3. Technological characteristics of fruit

Genotype	Technological weight g	Placenta weight g	Seed weight g	Biotechnological weight g
Cf SF 1	55 a	11.5 a	3.48 a	38.5 a
Cf SF 2	28 b	4.7 b	2.56 b	19.0 b

The technological weight of fruits in Cf SF 1 line was nearly twice as big as the other of the two (Tab. 3). The scope of differences related to the weight of placenta was bigger. The placenta of the above-mentioned line was nearly two and a half times heavier. However, differences relating to the weight of seeds were definitely smaller. Here, the conclusion that can be made points to the lack of a directly proportional relation between the weight of the placenta and fertility, understood as the number of seeds per fruit.

Similar observations may be also made analysing results of research carried out by Wang and Wang [1996]. During the above-mentioned experiments, the share of the edible part in the total weight of the fruit including the pedicle was also determined. Extreme values reached the level of 86% and 63%. It must be added that the afore-mentioned results refer to hard-flesh forms, that is, forms that are commonly known to us and that are commonly cultivated. The above-mentioned note is significant since in these forms the skin of the fruit is classified as the edible part. For soft-flesh materials it is necessary to reclassify this part of the fruit. In the flesh production process, it becomes a redundant component that is not included in the final product. The skin itself constitutes a very small part of the fruit; however, in the course of processing also the part of the pericarp that adheres to the same is treated as waste. As follows from the comparison of results concerning the biotechnological weight of the fruit and the weight of the placenta and seeds, the average loss corresponding to the same amounted to about 3%. They were higher in smaller fruits, which seems obvious with regard to the relatively higher share of skin in the weight of smaller fruits. The loss may be smaller if the technology involved in separation of flesh takes into account some share of water in the production process.

Having the ready results at our disposal, we can estimate the yield of production, taking into account cultivation of plants as the source of the raw material. The average biotechnological performance of the fruits (share of the average biotechnological weight in the average technological weight of the fruit) was 68 %. The difference between the average weight of the fruit (Tab. 2) and the technological weight (Tab. 3) was respectively 6 g and 3 g for both lines. In relative values, the process weight, expressed as the average value for both lines, constituted 90 % of the average weight of the fruit. Assuming identical yield of mature crops, we can expect to obtain about 2 kg of concentrated juice from fruits picked per 1 m^2. Such a yield cannot be considered high if the final product is going to be an ordinary food product. It must be regarded as biologically active food or, if some conditions concerning standard nature of the product are satisfied, as a nutraceutic. The content of substances active in terms of prophylactics and treatment provides full justification for the above-mentioned presentation of the issue. Work is being carried out to improve the effectiveness of production of the raw material and processing of the same through creation of interspecies hybrids with high-yield cultivable forms of annual pepper.

CONCLUSION

The pedigree selection we have used in *Capsicum frutescens* L. breeding lets us obtain two soft-flesh lines being an interesting raw material for processing.

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