

## Open Pollinated Broccoli Genotypes: Agronomic Parameters and Sensory Attributes

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### Abstract

Breeding of open pollinated (OP) varieties for organic farming gains further importance as varieties developed from CMS-hybridisation and cell fusion are no longer accepted by some organic farming associations. For broccoli (*Brassica oleracea* var. *italica*), the availability of OP varieties is very limited. In a participatory breeding project the German NGO Kultursaat e.V. and the University of Hohenheim tested new OP genotypes for agronomic parameters and sensory traits in 2012 and 2013. Agronomic traits of hybrids and OP genotypes varied widely. Some OP genotypes showed similar head weights and head diameters as the standard hybrids, while others were much lower in weight and head diameter. In the sensory assessments, untrained consumers were able to differentiate between the different genotypes. The OP genotype CHE-MIC showed the highest acceptance amongst consumers in both years. CHE-MIC has the potential to be commercially successful if further selection for homogeneity takes place.

### Introduction

Currently, broccoli (*Brassica oleracea* var. *italica*) has gained attention because of the struggles on patenting genotypes with high concentrations of glucosinolates showing positive effects in cancer treatment (Keck 2004). In addition, the ban on CMS-hybrids by some organic farming associations in Germany drew further attention to broccoli. Currently, only very few open pollinated (OP) varieties with unsatisfactory agronomic performance exist. To meet the demands of organic producers, breeding programmes for new OP varieties are required.

Such new OP broccoli varieties might differ in outer appearance and sensory traits from the formerly used hybrids. Whether or not consumers accept such differences is often not known. Up to now the relation between taste and agronomic properties has not been assessed for open pollinated broccoli genotypes. Therefore, the objectives of the present study were to assess sensory attributes as well as the agronomic parameters of OPs in comparison to hybrids in order to select suitable genotypes for further breeding.

### Material and methods

In a participatory breeding project by the German NGO Kultursaat e.V. and the University of Hohenheim, 14 OP genotypes (selected by the on-farm breeders of Kultursaat e.V.), five hybrid varieties and three OP broccoli varieties that were available on the seed market were tested. Out of the complete set of genotypes four OP genotypes, one hybrid and one OP variety were used in 2012 for sensory evaluation; in 2013, two OP genotypes and one hybrid were used. The choice of the OP genotypes was based on breeding lines and time of optimum harvest.

The genotype screening was done at the organic experimental station Kleinhohenheim, University of Hohenheim, Stuttgart, Southern Germany (435 m above sea level, average annual precipitation of 700 mm, average annual temperature 8.8°C) for two cultivation periods (spring 2012 and 2013) in field trials with a randomized block design. Cultivation was done according to local best practice for organically grown broccoli. Agronomic parameters like weight of heads and head colour were assessed for three plants per genotype / variety every week starting at the onset of harvesting. Colours of broccoli heads were assessed using a scale from 1 to 9 (1 = green, 3= greyish green, 6=blue green and 9= violet).

Sensory tests were performed with an untrained consumer panel at two dates in spring 2012 and at two dates in spring 2013. The tasting was performed using cooked and raw broccoli heads. The samples were cooked under standardized conditions for three minutes. The room where the tasting took place was shaded to limit the bias resulting from different colours of the samples. The panel was divided into two groups and each test person received the samples in different, randomized order. In 2012, the panel tasted three OP

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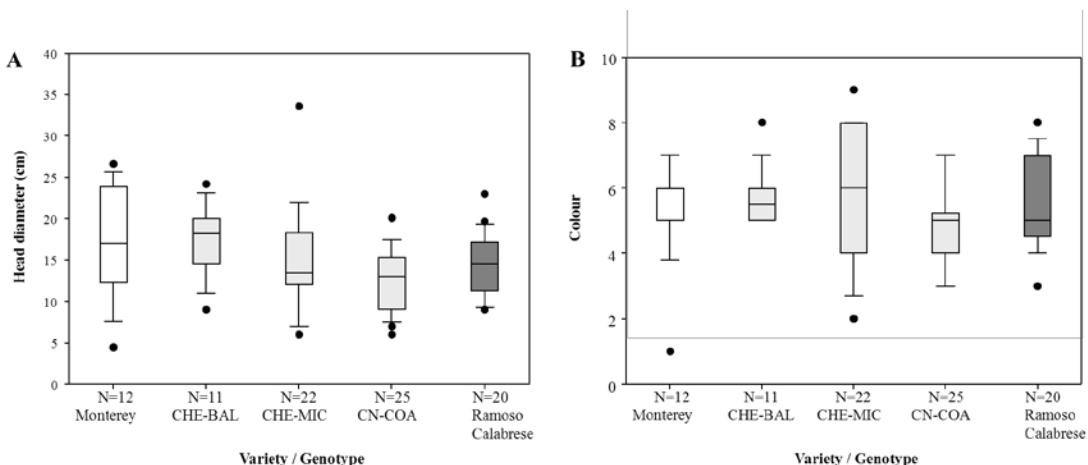
genotypes, one hybrid and one commercially available OP variety. In 2013, two OP genotypes and one hybrid were used and one randomly selected repeater sample was added to check the validity of the answers. During both tests the panel members had to fill in a questionnaire with open and multiple-choice answers on the sensory attributes of the samples.

The data on agronomic traits as well as the data on the sensory attributes were statistically analysed using ANOVA/mixed model (SAS 9.3).

## Results

At each harvesting date, all marketable heads (diameter > 7 cm) were used for the determination of agronomic traits. Mean head weights of the varieties / genotypes used for sensory testing ranged from 380 g for the OP genotype CHE-BAL and 340 g for the hybrid Monterey to 241 g for the commercial OP variety Ramoso Calabrese in 2012. Median head diameters ranged from 18 cm for the OP variety CHE-BAL to 13 cm for the OP genotype CN-COA (Fig. 1). CHE-BAL and the hybrid Monterey showed a similar median head diameter. CHE-MIC, the genotype which performed best in the sensory tests (Tab. 1), showed a much lower head diameter of 13.5 cm (Fig. 1). The hybrid Monterey and the OP genotype CHE-BAL had a very similar colour of blue green homogenously expressed by the crop stand. On the contrary, the OP genotype CHE-MIC showed a large heterogeneity in colour, some plants were violet while others had a greenish colour (Fig. 1).

Tastings of cooked broccoli with an untrained consumer panel showed significant differences according to the attribute "popularity" (Tab.1). In both years the OP genotype CHE-MIC ranked highest in the attribute "popularity". Low "popularity" was attributed to Ramoso Calabrese in 2012 and genotype CHE-GEBA in 2013. The taste attributes "nutty", "cabbage like", "spicy" and "bitter" showed significant differences among the broccoli genotypes and hybrids as well. High popularity values were determined by the attributes "nutty" and "sweet" and low values in the attributes "bitter", "spicy" and "off-flavour". The ranking for raw broccoli differed from the ranking for cooked material (data not shown). For the attribute "popularity" significant differences could only be found in 2012 for CN-COA and Monterey respectively.



**Fig. 1: Agronomic parameters head diameter (A) and colour (B) of broccoli hybrids (Monterey), a commercially available open pollinated variety (Ramoso Calabrese) and open pollinated genotypes (CHE-BAL, CHE-MIC, CN-COA); Colour is ranked from green (1) to violet (10); N = number of observations; Boxplots: Black line = median, Box = 25% and 75% percentiles, whiskers = 10% and 90% percentiles, dots = outliers**

In both trials, untrained consumers were able to assign different attributes to broccoli varieties and differentiate clearly between the varieties, but the personal factor and the date of tasting showed a strong influence on the results (data not shown). On an overall level, the OP genotype CHE-MIC performed best (highest ranking for "popularity") in both years in the tastings for cooked material, while the OP genotype CHE-GEBA showed the lowest ranking in 2013 for cooked tastings. In 2012, the lowest acceptance when cooked was assigned to the OP variety Ramoso Calabrese.

## Discussion

Consumer preferences were assessed only for the taste, but not for the appearance of the different genotypes and varieties. As consumers are used to the taste and outer appearance of hybrids, it remains unclear whether they will accept the genotype CHE-MIC with its high heterogeneity in colour and its rather low head diameter. If organic traders are willing to deal with a product that is heterogeneous in colour and in size, is an open question unless marketing strategies for premium prices based on the added value of open pollinated varieties become successful. In addition, organic producers will probably refrain from using such genotypes, which may generate lower numbers of marketable heads and therefore lower revenue. For these reasons further breeding activities based on the genotype CHE-MIC are necessary.

**Table 1: Ranking of different taste attributes during two sensory testings of cooked Broccoli hybrids (Monterey, Batavia), commercially available open pollinated variety (Ramoso Calabrese) and open pollinated genotypes (CN-COA, CHE-MIC, CHE-GEBA, CHE-GRE)**

| Attributes                                    | Sensory Testing      |                                 |                       |                       |
|---|----------------------|---------------------------------|-----------------------|-----------------------|
|   | 2012                 |                                 | 2013                  |                       |
| Ranking                                       | highest              | lowest                          | highest               | lowest                |
| Overall popularity                            | CHE-MIC <sup>a</sup> | Ramoso <sup>b</sup>             | CHE-MIC <sup>a</sup>  | CHE-GEBA <sup>b</sup> |
| <b>Positively associated taste attributes</b> |                      |                                 |                       |                       |
| Sweet   | CN-COA <sup>a</sup>  | Ramoso <sup>a</sup>             | CHE-MIC <sup>a</sup>  | CHE-GEBA <sup>a</sup> |
| Nutty   | CHE-MIC <sup>a</sup> | Monterey <sup>b</sup>           | CHE-MIC <sup>a</sup>  | Batavia <sup>a</sup>  |
| Cabbage-like                                  | CN-COA <sup>a</sup>  | Monterey <sup>a</sup>           | Batavia <sup>a</sup>  | CHE-GEBA <sup>b</sup> |
| Spicy   | CHE-GRE <sup>a</sup> | Ramoso <sup>a</sup>             | Batavia <sup>a</sup>  | CHE-MIC <sup>b</sup>  |
| <b>Negatively associated taste attributes</b> |                      |                                 |                       |                       |
| Bitter  | CN-COA <sup>a</sup>  | CHE-MIC + Monterey <sup>a</sup> | Batavia <sup>a</sup>  | CHE-MIC <sup>b</sup>  |
| Off-flavour                                   | CHE-GRE <sup>a</sup> | CHE-MIC <sup>a</sup>            | CHE-GEBA <sup>a</sup> | CHE-MIC <sup>a</sup>  |

Different letters indicate significant differences at the level p<0.01, \*=two genotypes/varieties show the same ranking

For cooked broccoli consumers of an untrained sensory panel preferred OP genotypes rather than hybrid varieties. The genotype CHE-MIC is promising and could be used for further breeding efforts given taste is the central criterion for selection because its sensory traits outperformed the other OP genotypes and the hybrids. The large heterogeneity of the crop stand may be further limited by continued breeding activities. Nevertheless, it remains open if an OP variety will reach a level of uniformity comparable to hybrids. In addition, colour or head shape may differ from what consumers are used to. Therefore further trials and/or information exchange with consumers, producers and traders are necessary to improve the acceptance of these OP varieties.

Within the project, a workshop with stakeholders along the organic food chain was done to include their views in a participatory breeding approach to develop OP broccoli varieties which are widely accepted. Besides taste, agronomic performance, harvest times and outer appearance of the heads were discussed as crucial selection criteria by the stakeholders from trade and agriculture.

## References

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